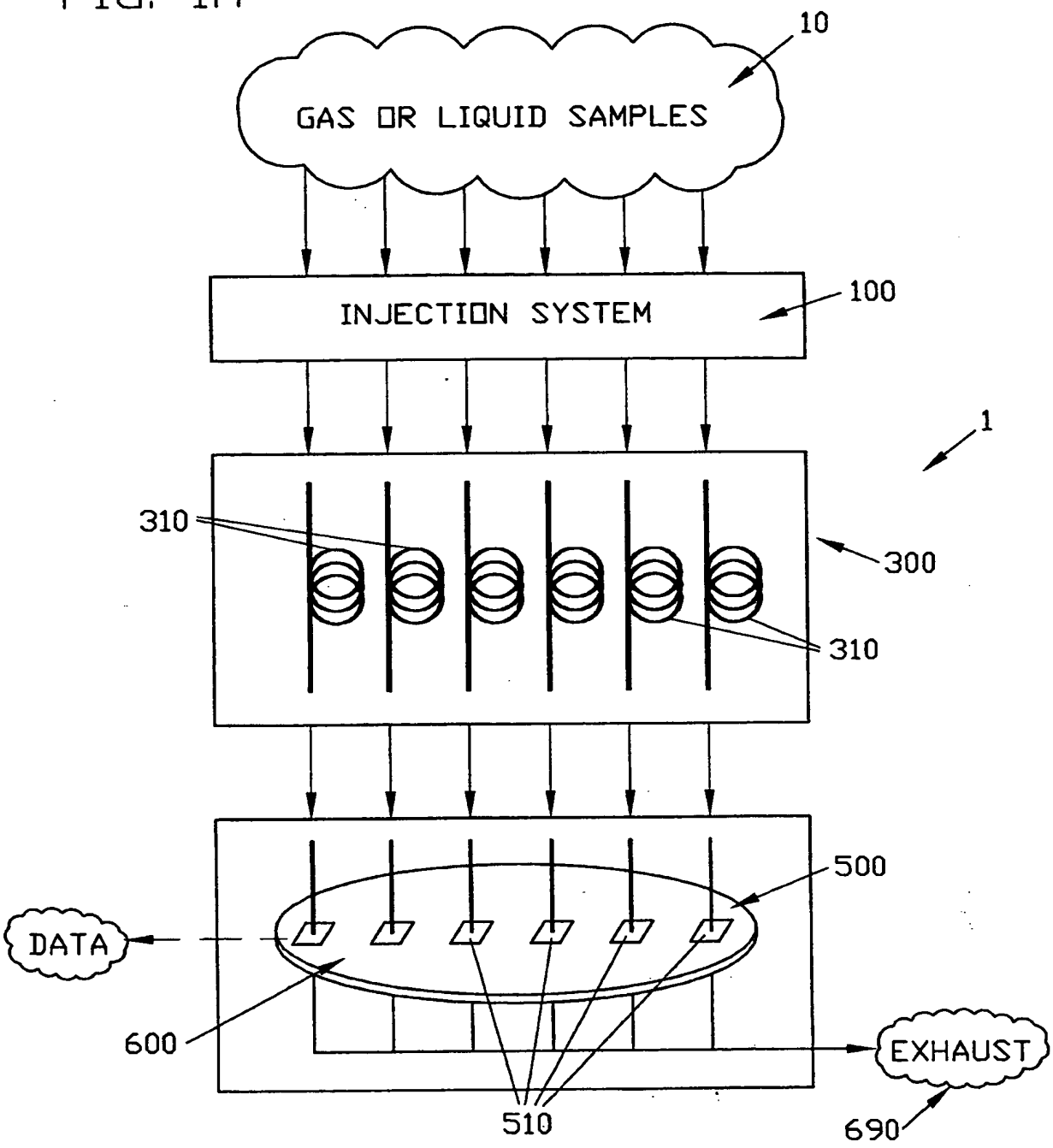
FIG. 1A


10
GAS OR LIQUID SAMPLES
INJECTION SYSTEM
100
1
310
300
310
500
DATA
600
EXHAUST
690
510

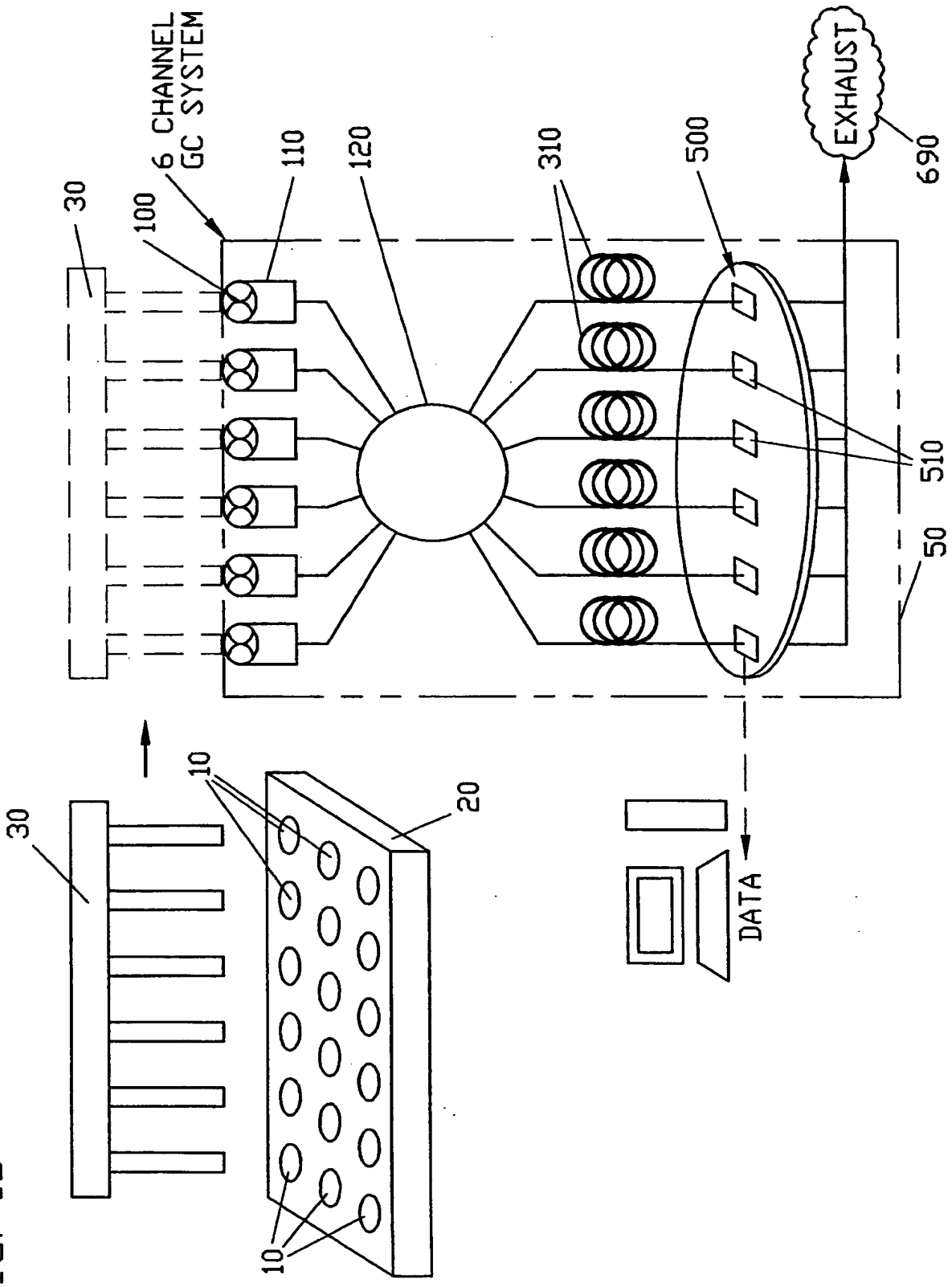

6 CHANNEL
GC SYSTEM
30
100
110
120
310
500
EXHAUST
690
510
50
10
20
30
10
DATA

FIG. 1B

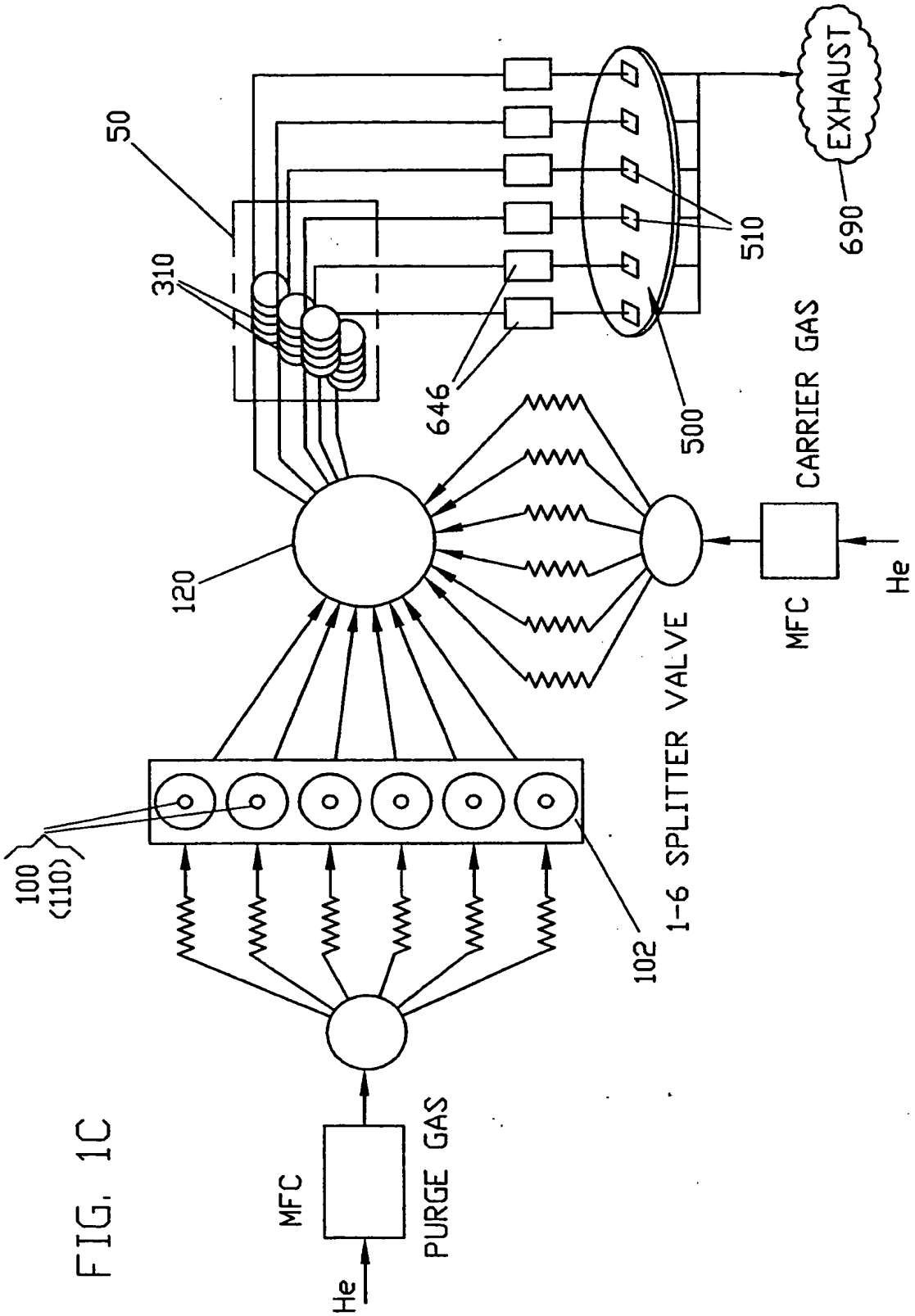

50
310
646
500
510
690
EXHAUST
CARRIER GAS
He
MFC
120
1-6 SPLITTER VALVE
100
<110>
102
MFC
PURGE GAS
He

FIG. 1C

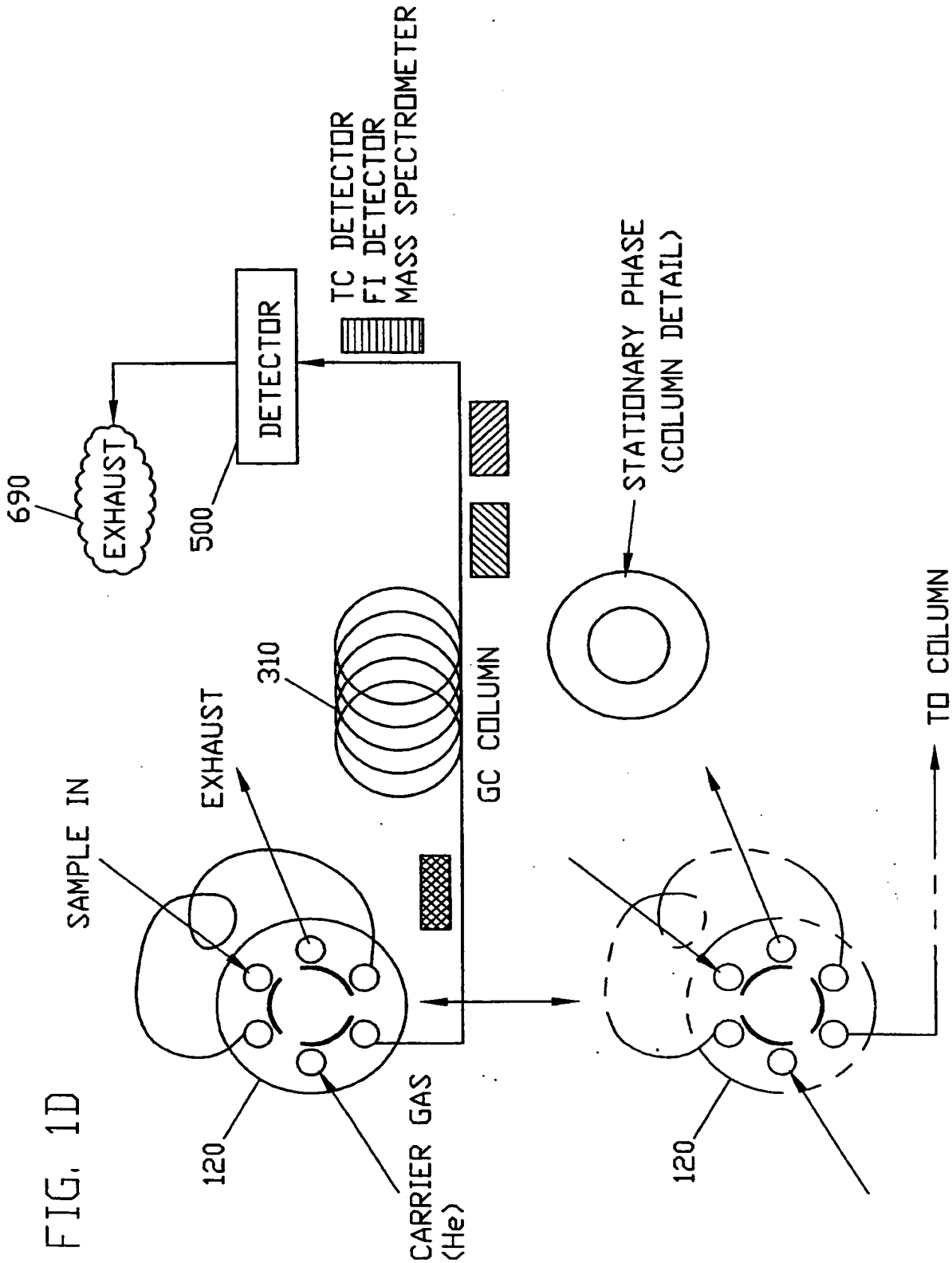

690
EXHAUST
500
DETECTOR
TC DETECTOR
FI DETECTOR
MASS SPECTROMETER
STATIONARY PHASE
(COLUMN DETAIL)
310
GC COLUMN
SAMPLE IN
EXHAUST
TO COLUMN
120
CARRIER GAS
(He)
120

FIG. 1D

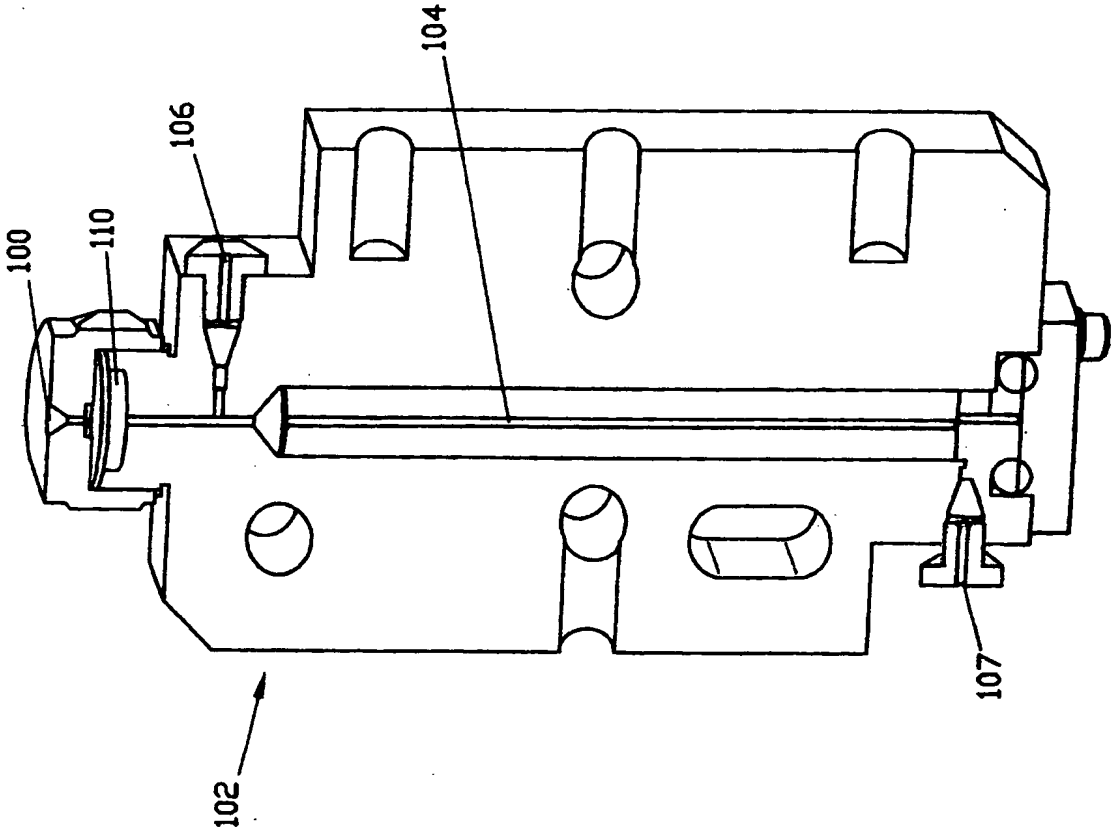


FIG. 2A

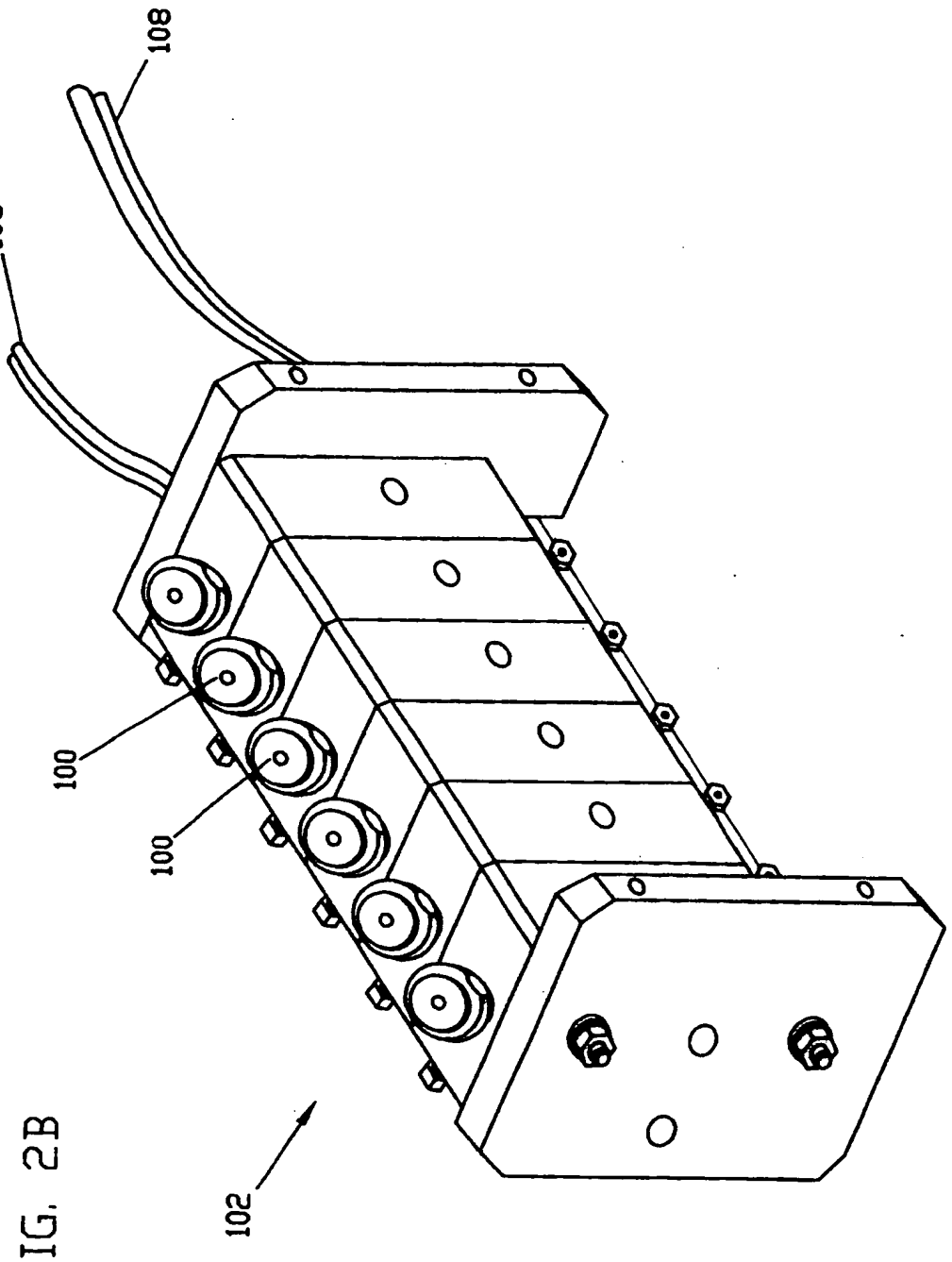


FIG. 2B

FIG. 2C

INJECTION PORT CROSS SECTION

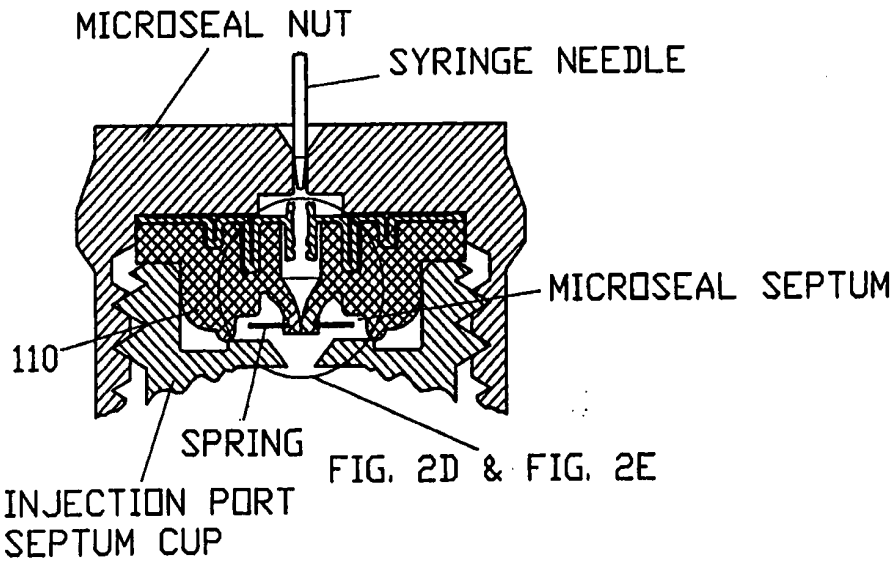


FIG. 2D & FIG. 2E

FIG. 2D

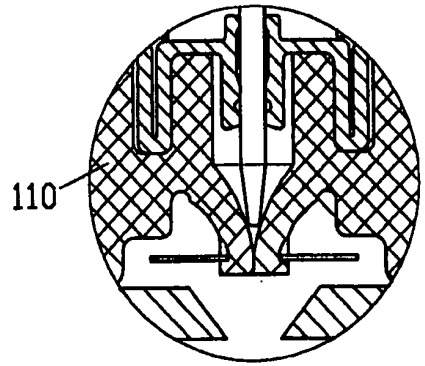
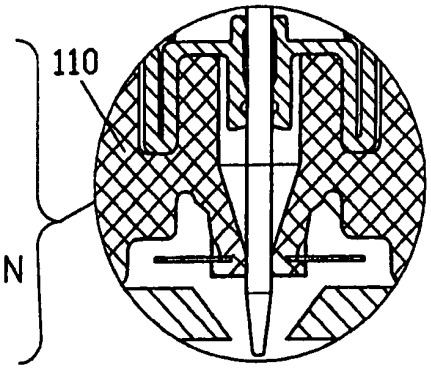


FIG. 2E



INJECTION SEQUENCE

1. SLIDING SEAL IS MADE AROUND NEEDLE AS IT IS INSERTED
2. SYRING NEEDLE FORCES DUCKBILL LIPS TO OPEN
3. SAMPLE INJECTED
4. SPRING FORCES DUCKBILL CLOSED AS NEEDLE IS WITHDRAWN
5. NEEDLE IS REMOVED FROM SLIDING SEAL

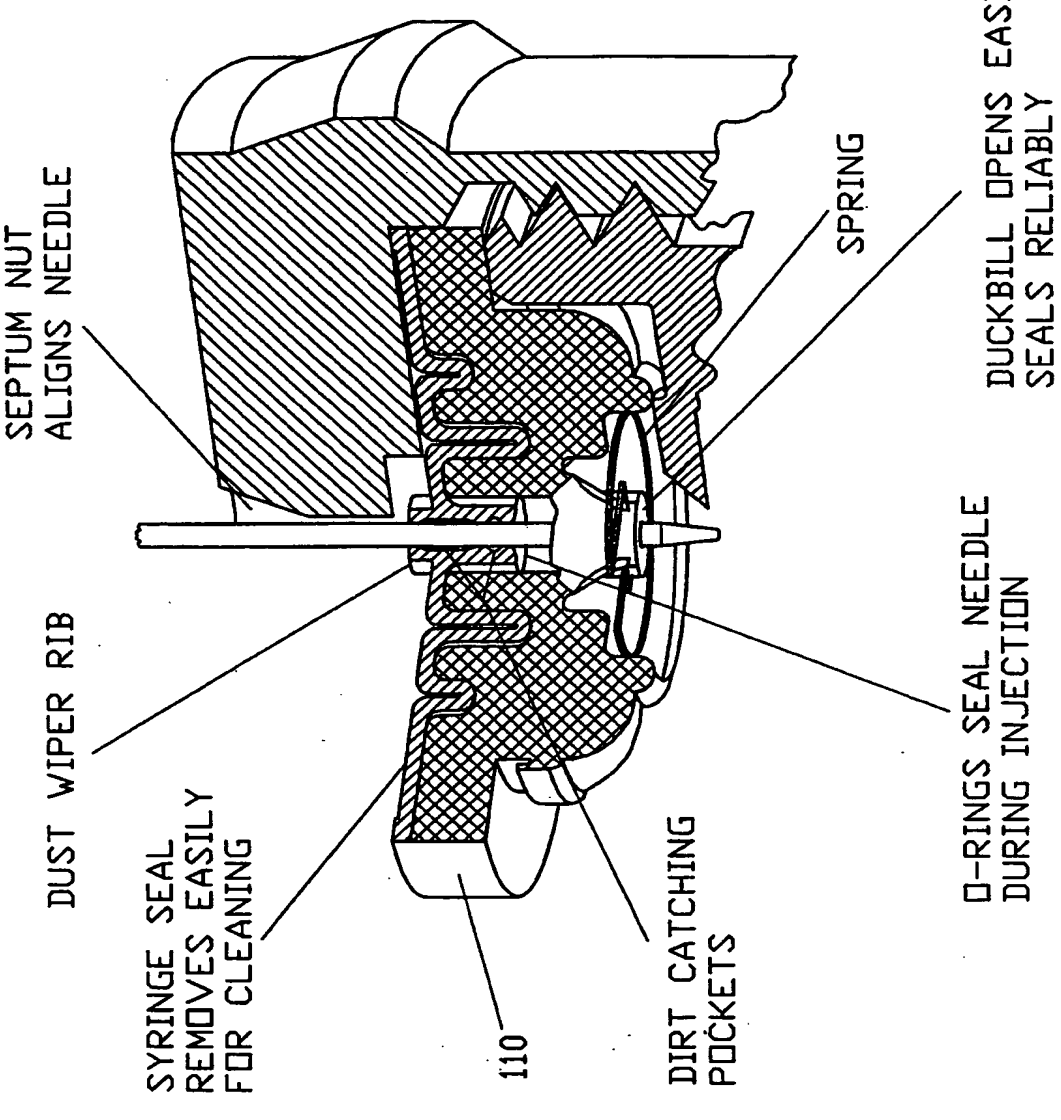

SEPTUM NUT
ALIGNS NEEDLE
DUST WIPER RIB
SYRINGE SEAL
REMOVES EASILY
FOR CLEANING
110
DIRT CATCHING
POCKETS
O-RINGS SEAL NEEDLE
DURING INJECTION
SPRING
DUCKBILL OPENS EASILY
SEALS RELIABLY

FIG. 2F

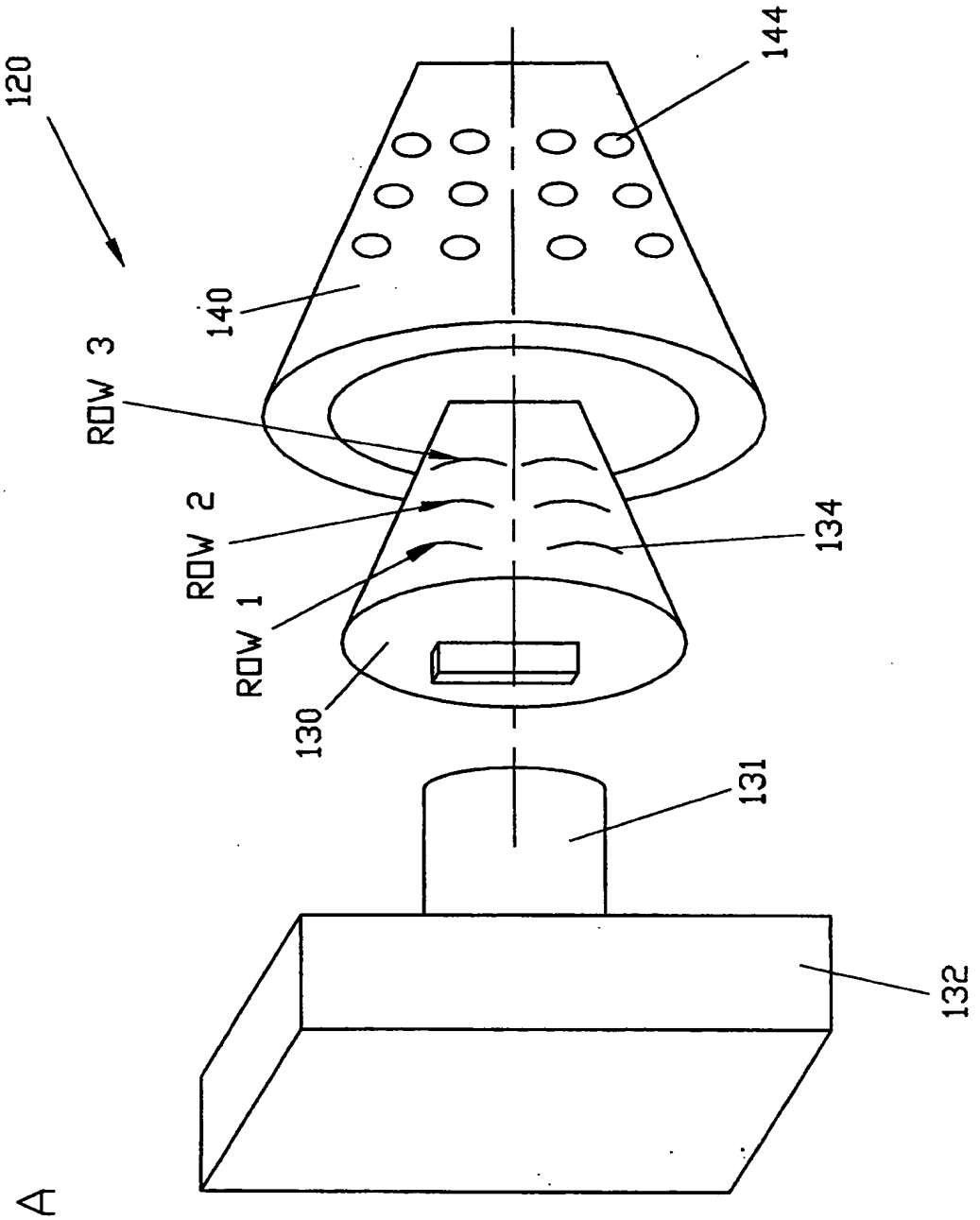


FIG. 3A

FIG. 3B

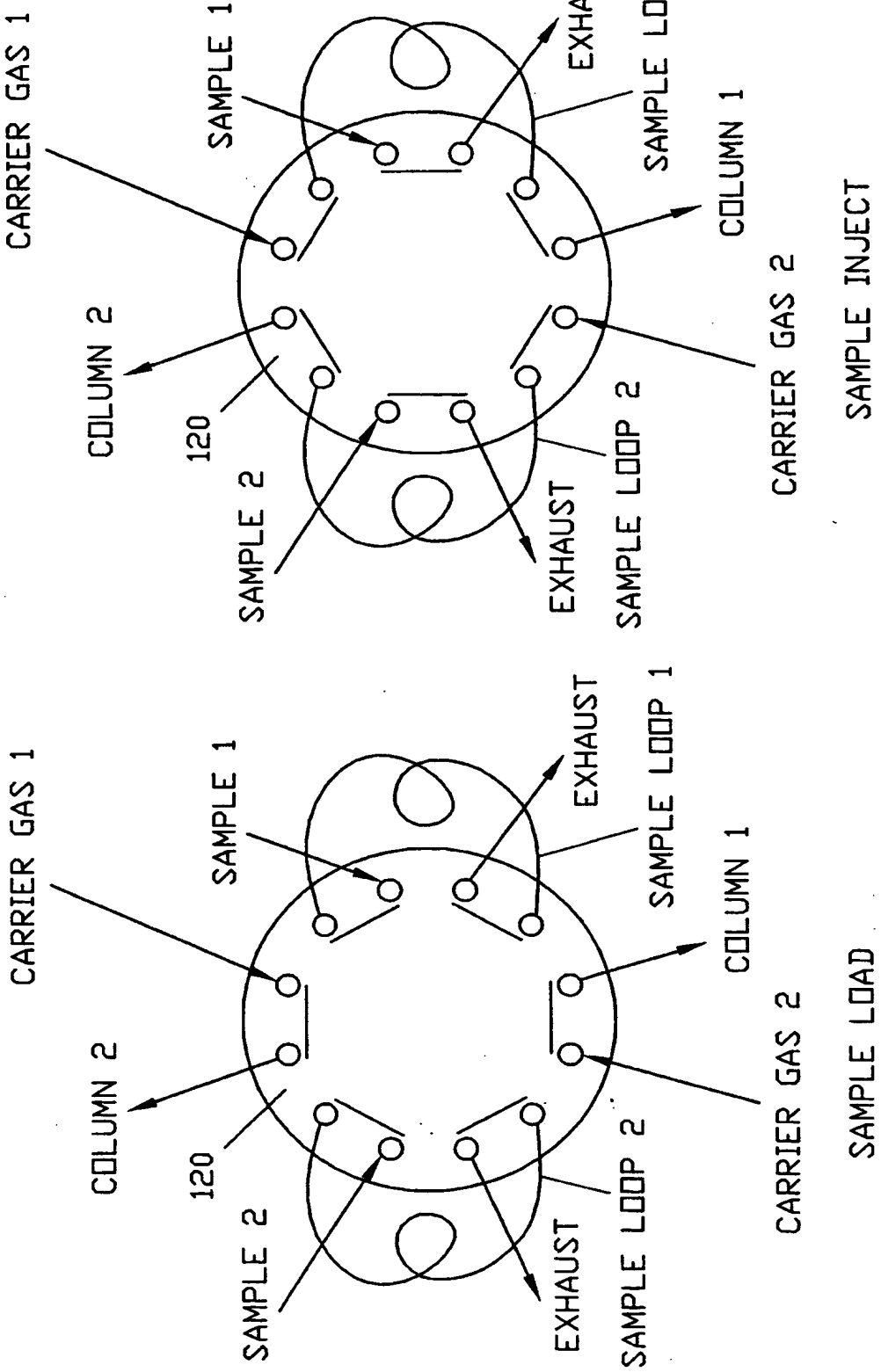
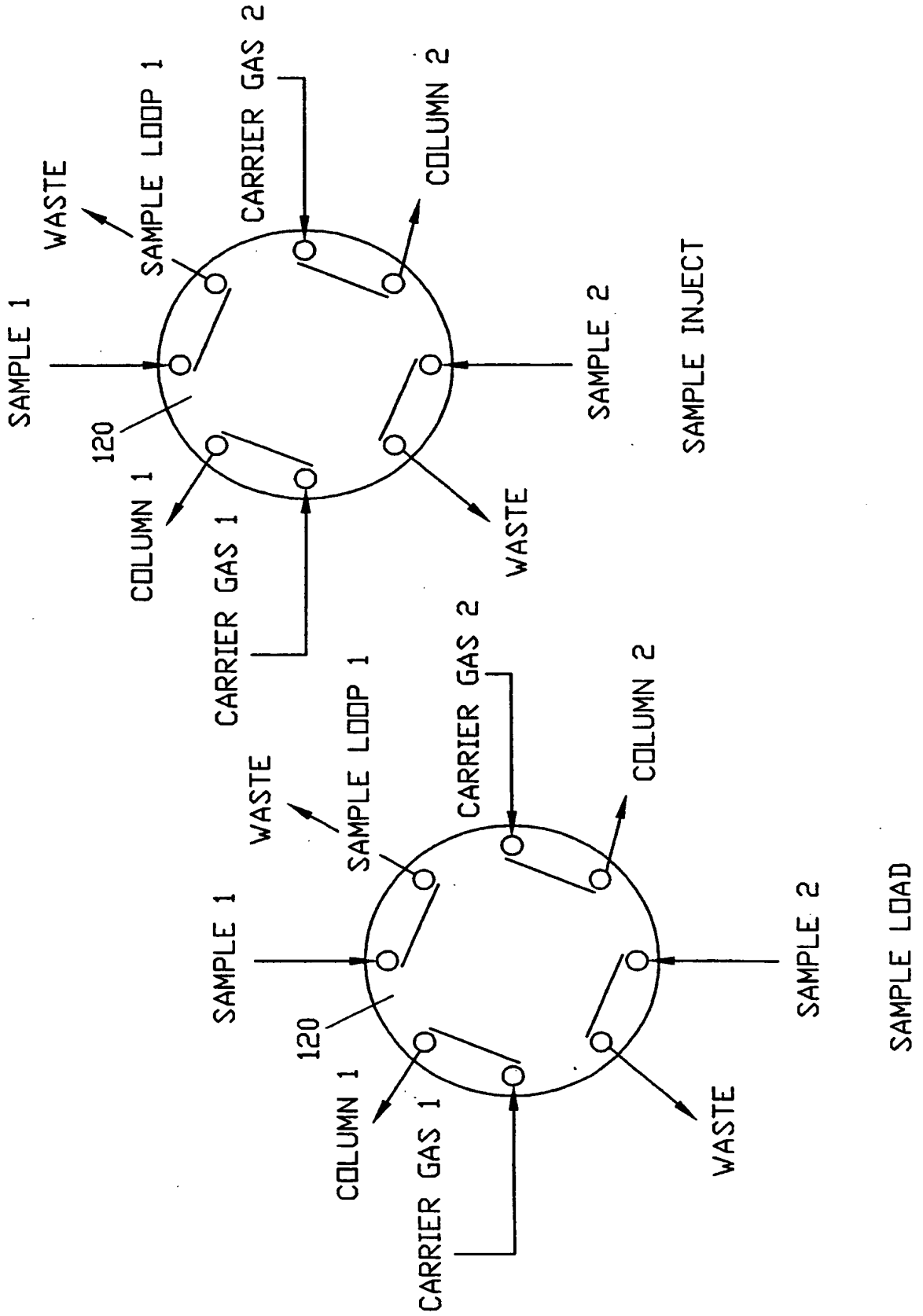

CARRIER GAS 1
SAMPLE 1
EXHAUST
SAMPLE LOOP 1
COLUMN 2
120
COLUMN 1
SAMPLE 2
EXHAUST
SAMPLE LOOP 2
CARRIER GAS 2
SAMPLE INJECT
CARRIER GAS 1
SAMPLE 1
EXHAUST
SAMPLE LOOP 1
COLUMN 2
120
COLUMN 1
SAMPLE 2
EXHAUST
SAMPLE LOOP 2
CARRIER GAS 2
SAMPLE LOAD

FIG. 3C


SAMPLE 1
WASTE
SAMPLE LOOP 1
CARRIER GAS 2
COLUMN 2
SAMPLE 2
SAMPLE INJECT
120
COLUMN 1
CARRIER GAS 1
WASTE
SAMPLE 1
WASTE
SAMPLE LOOP 1
CARRIER GAS 2
COLUMN 2
SAMPLE 2
SAMPLE LOAD
120
COLUMN 1
CARRIER GAS 1
WASTE

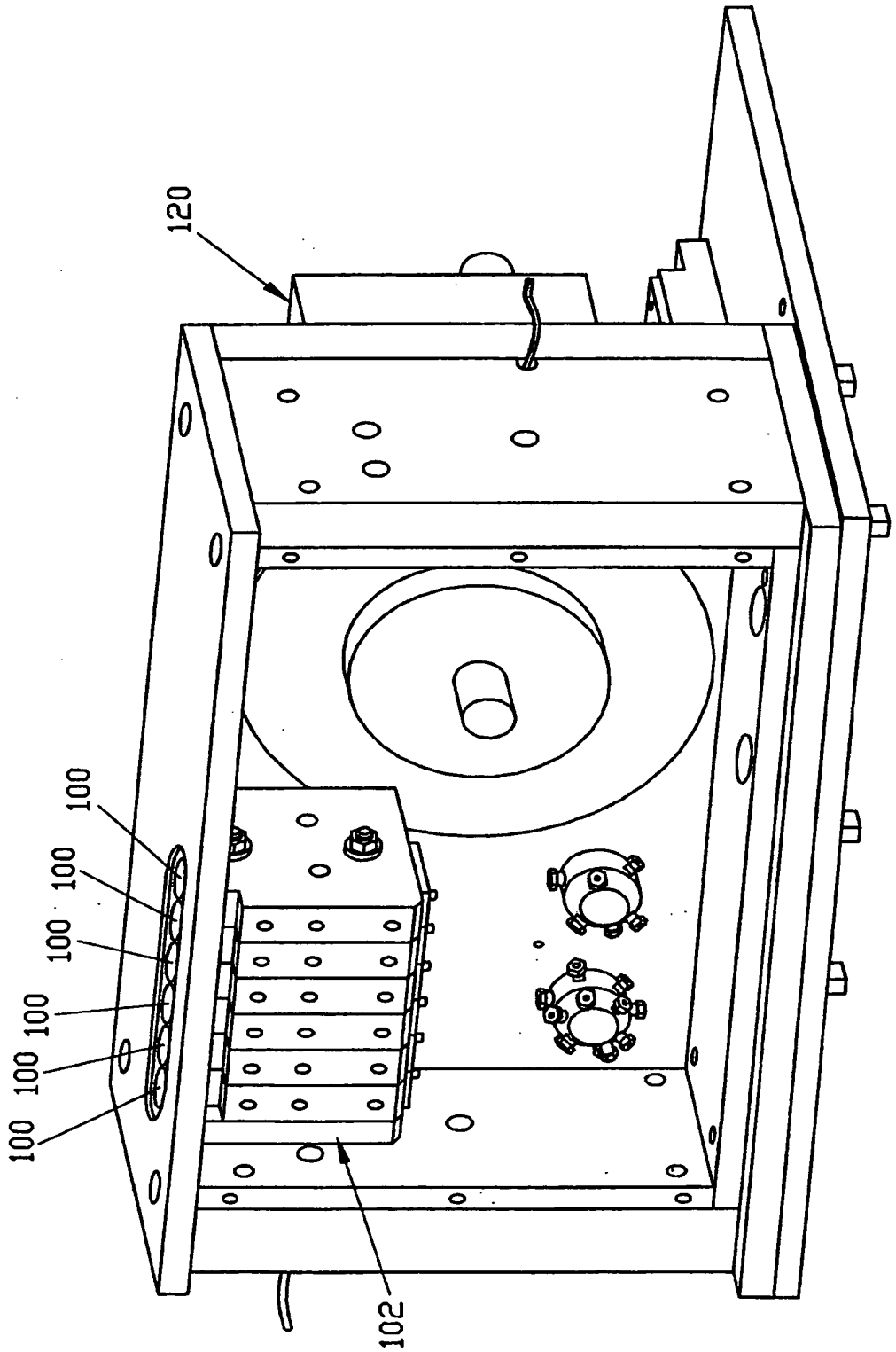


FIG. 4

FIG. 5A

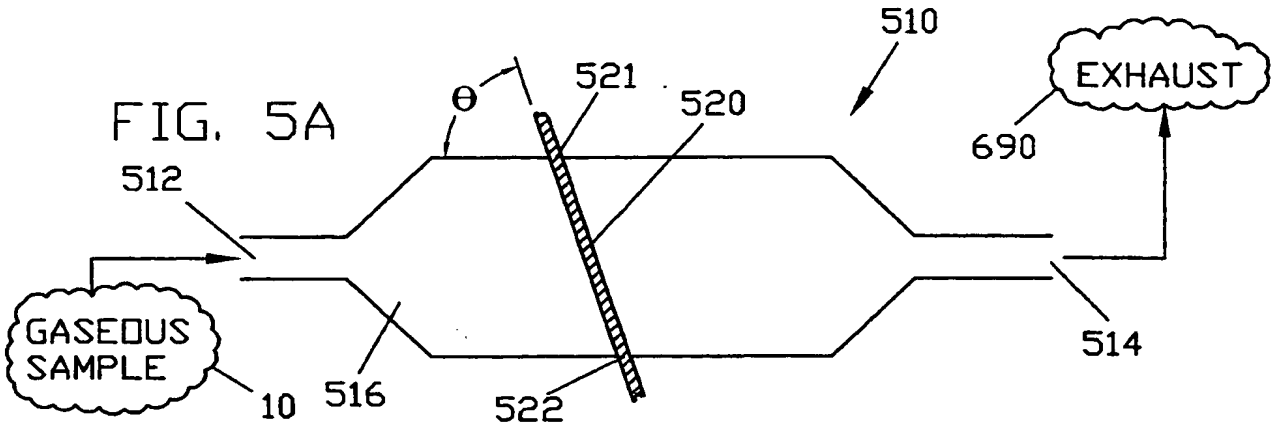


FIG. 5B

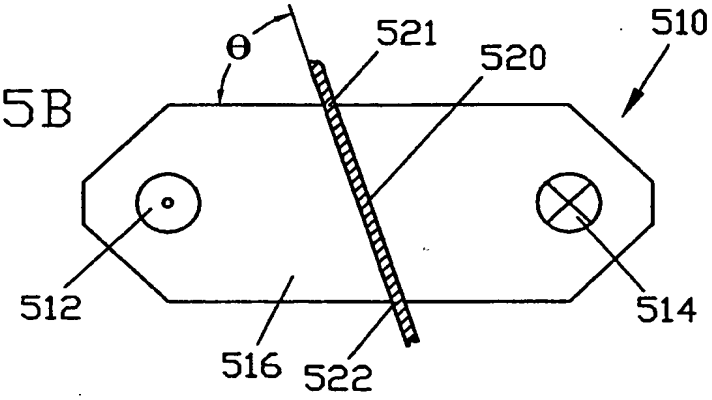


FIG. 5C

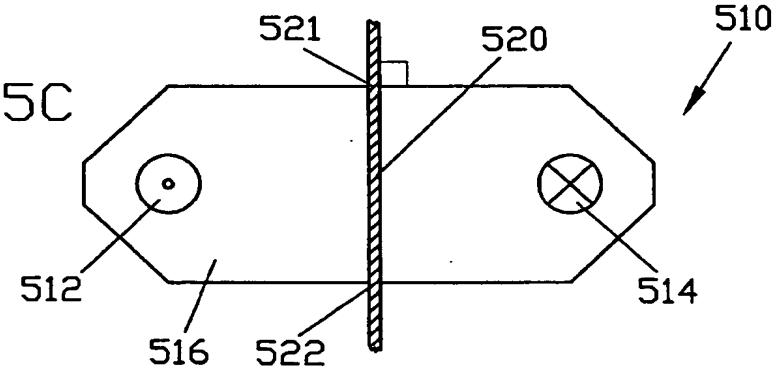


FIG. 5D

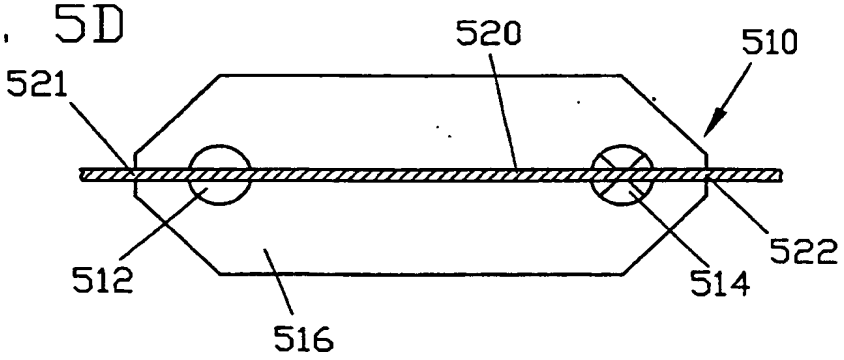


FIG. 5E

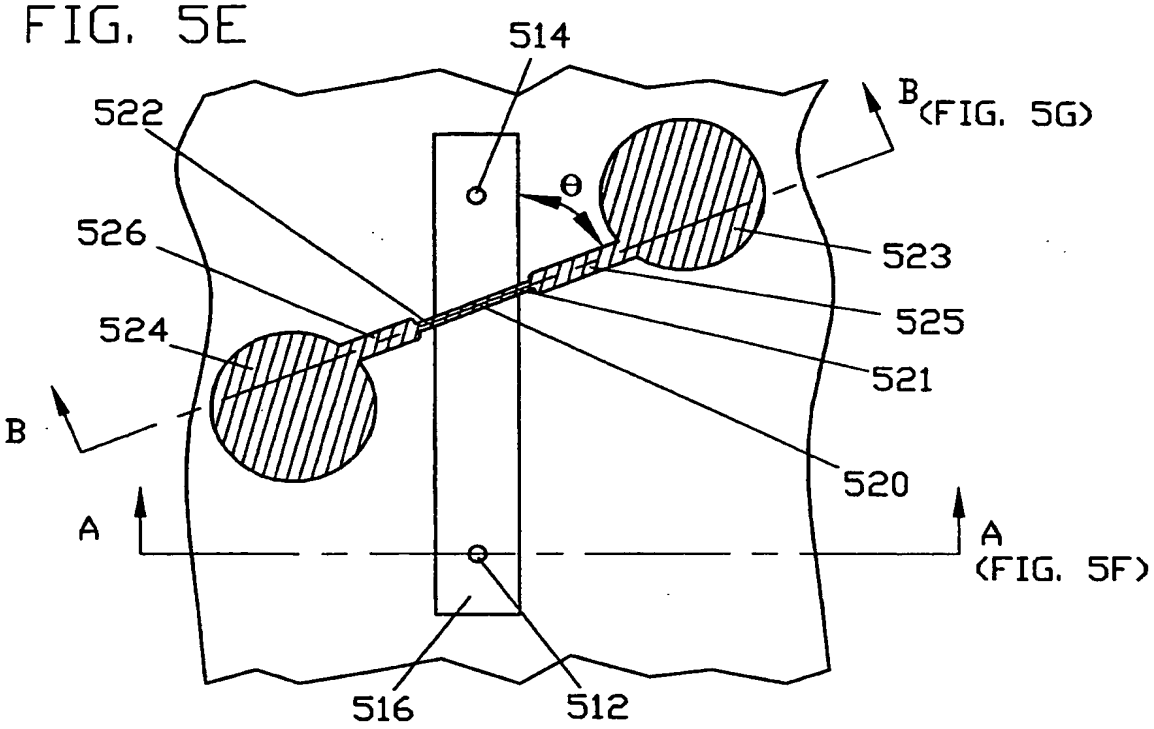


FIG. 5F

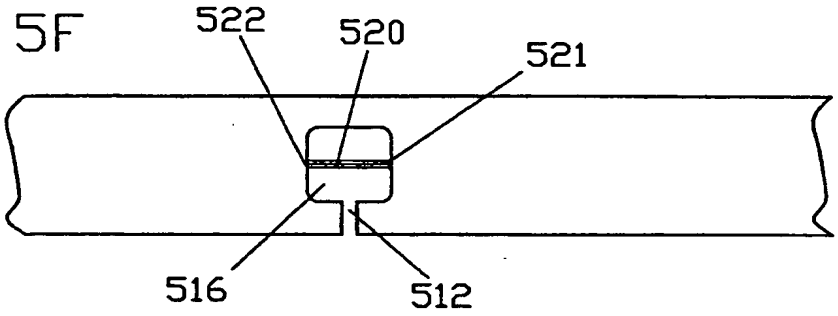
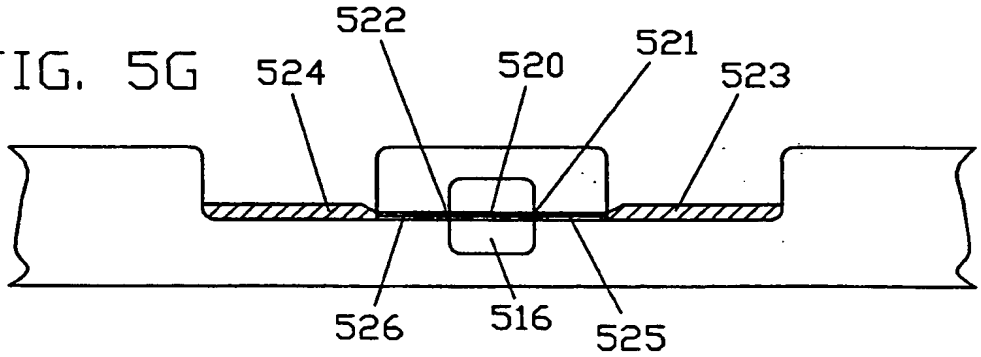


FIG. 5G



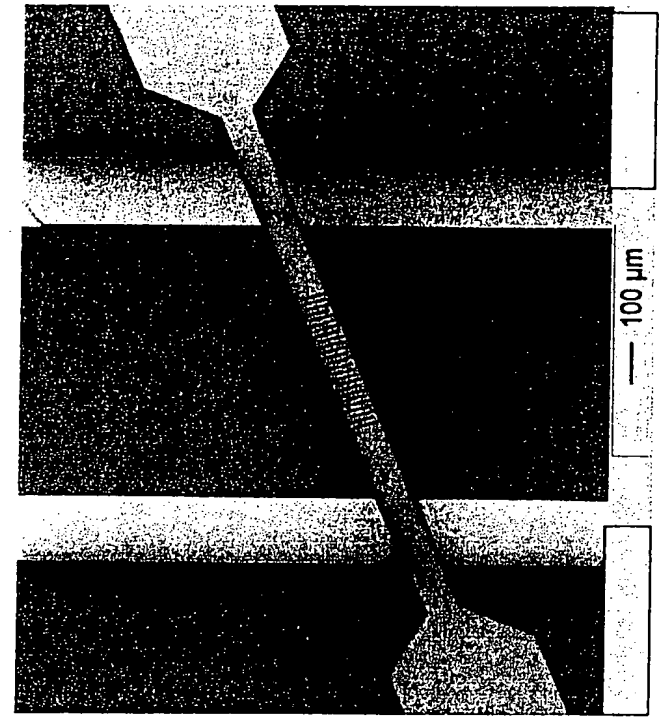


FIG. 5I

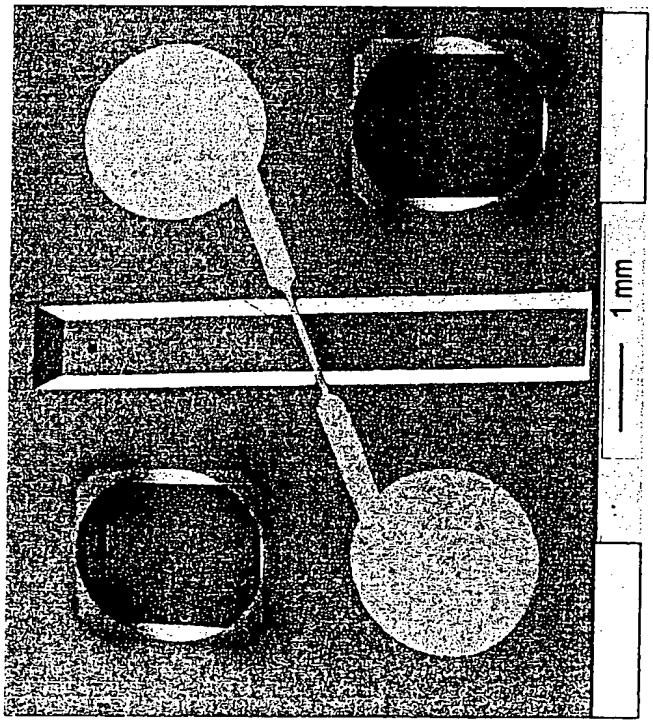
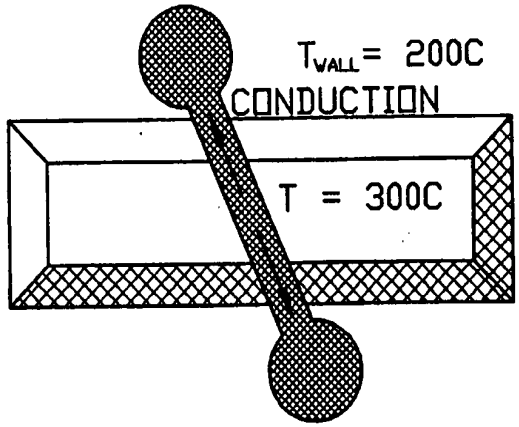


FIG 5H.

FIG. 5J

HEAT TRANSFER CALCULATIONS FOR TDC DESIGN



*CONDUCTION VIA LEADS TO FRAME

$$Q_{conduction} = \frac{k}{L} * A * \Delta T$$

$$Q_{conduction} \sim 0.2mW$$

*RADIATION

$$Q_{radiation} = \varepsilon * \sigma * A * (T_{hot}^4 - T_{ambient}^4)$$

$$Q_{radiation} = 1 * (5.67 * 10^{-8}) * (52\mu m * 1.5mm) * (573^4 - 473^4)$$

$$Q_{radiation} \approx 0.25mW$$

*CONVECTION

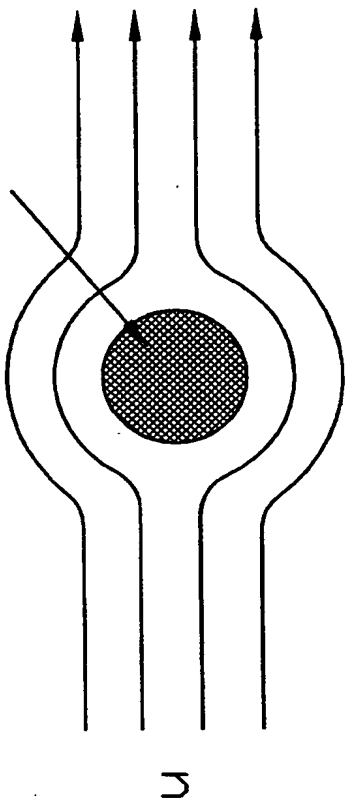
*CONVECTION INTO GAS DOMINATES

$$Q_{convection} = h * A * \Delta T$$

$$Q_{convection} = 1000 * (52\mu m * 1.5mm) * 100 = 8mW$$

FIG. 5K

CONVECTION HEAT TRANSFER FOR TDC DESIGN



$Q_{convection} = h * A * \Delta T$

$h \approx 2 * \frac{k}{D} + \frac{1}{2} * u * p * C_p$

REQUIRE-

$2 * \frac{k}{D} \gg \frac{1}{2} * u * p * C_p$

TDC VS. ANEMOMETER BEHAVIOR

FIG. 5L

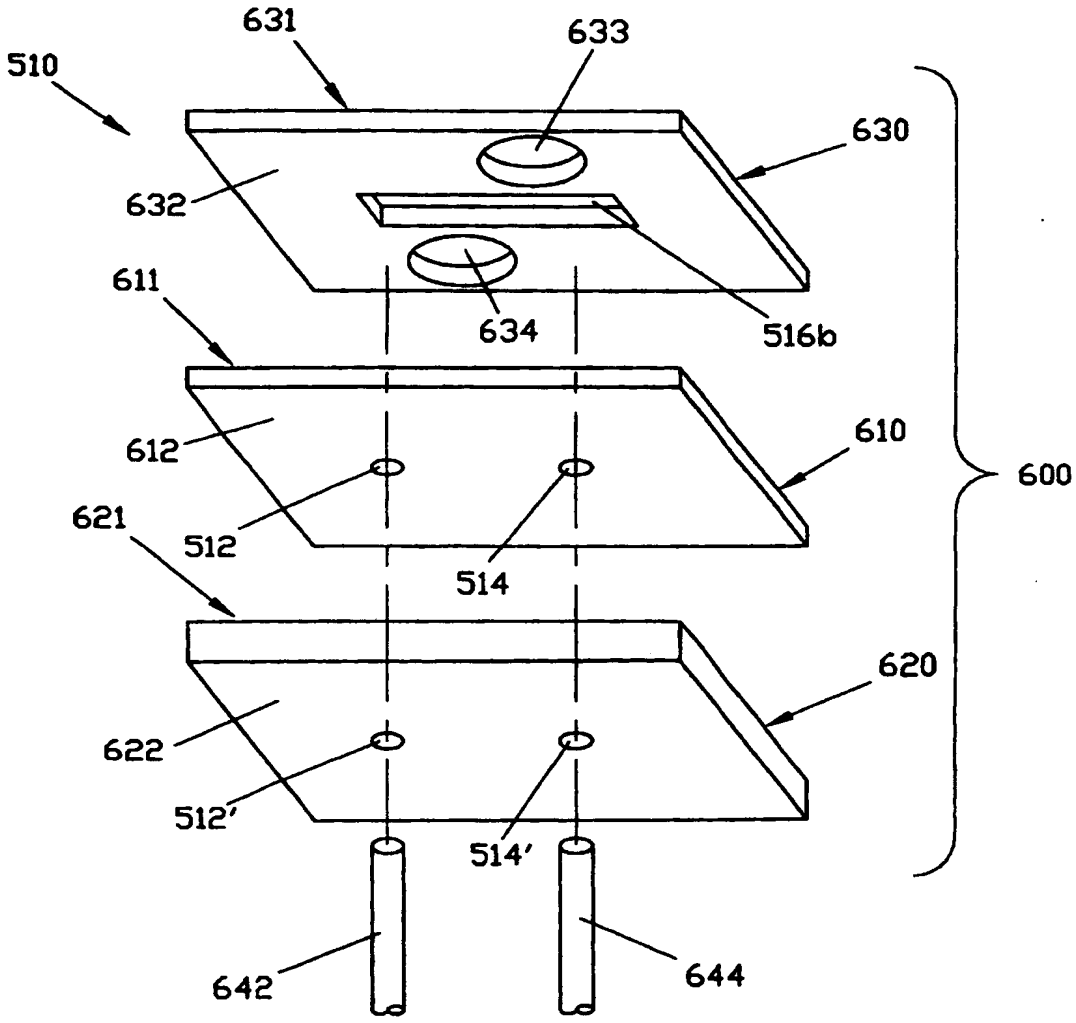

631
633
510
630
632
634
516b
611
610
612
600
621
512
514
620
622
512'
514'
642
644

FIG. 5M

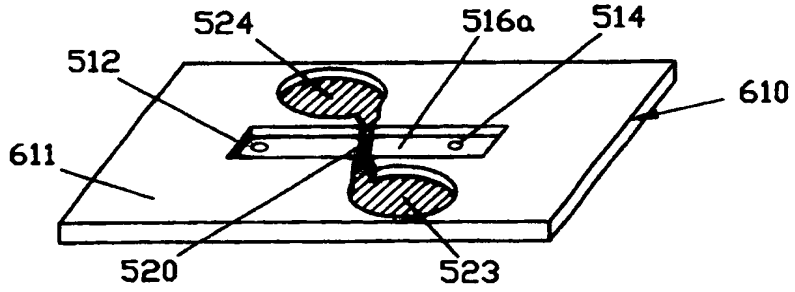

524
516a
514
512
610
611
520
523

FIG. 6A

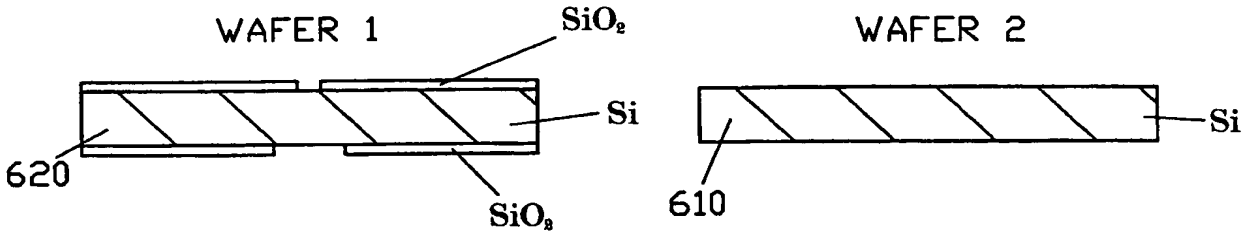


FIG. 6B

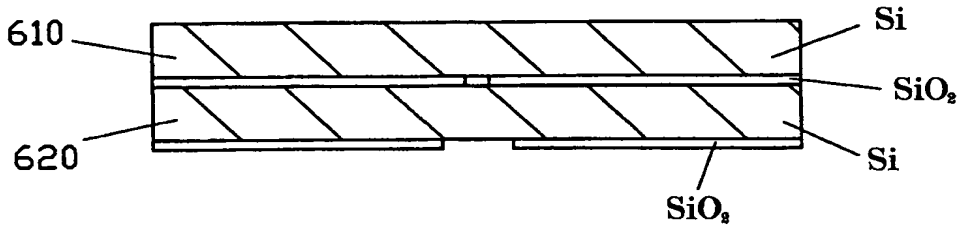


FIG. 6C

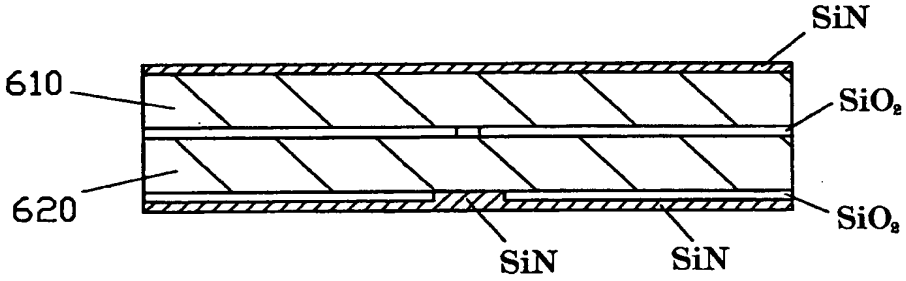


FIG. 6D

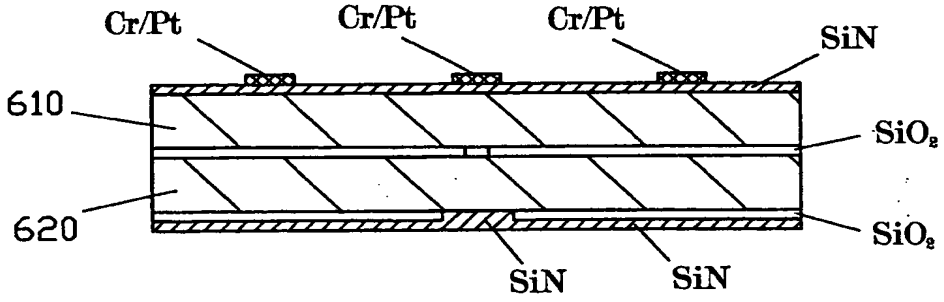


FIG. 6E

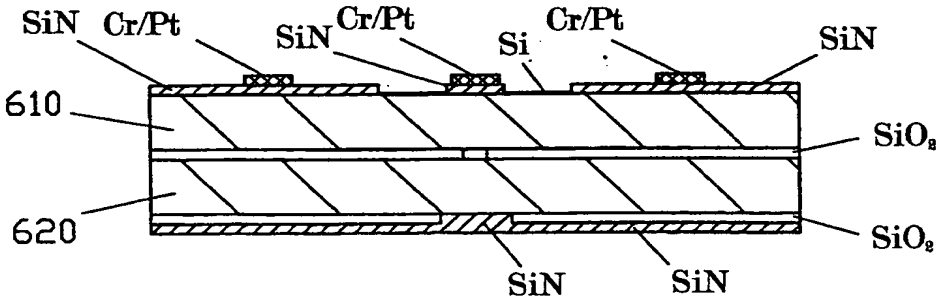


FIG. 6F

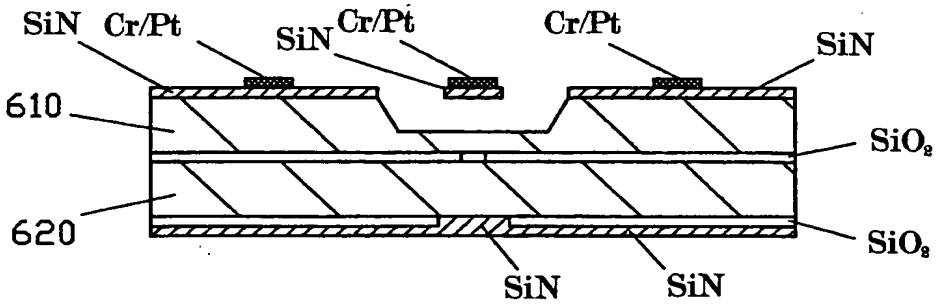


FIG. 6G

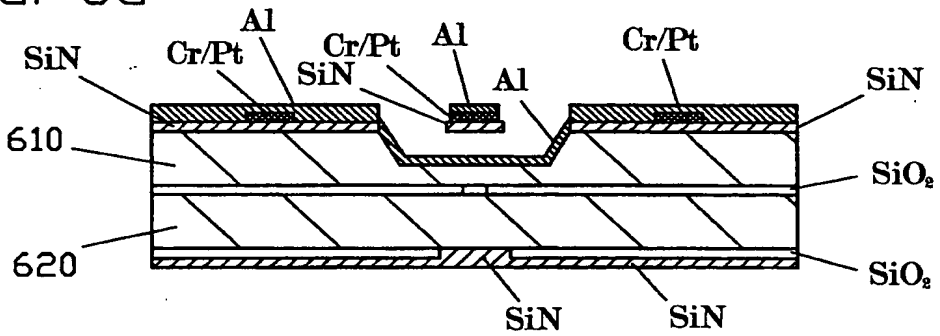


FIG. 6H

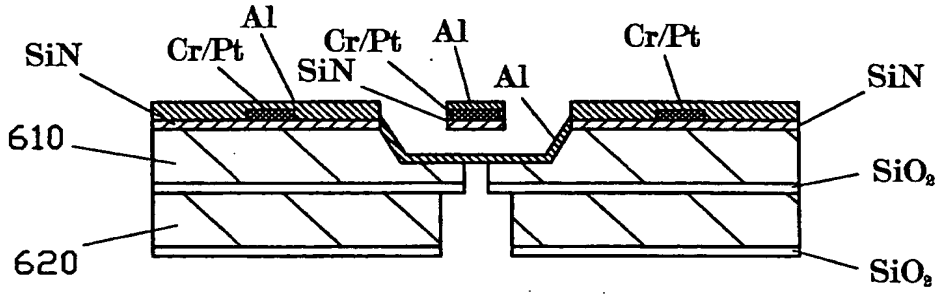


FIG. 6I

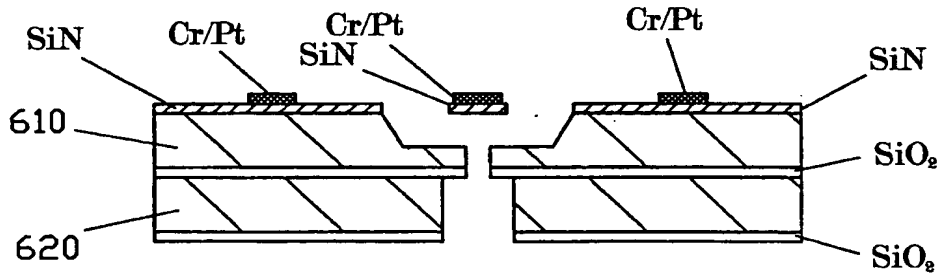


FIG. 6J

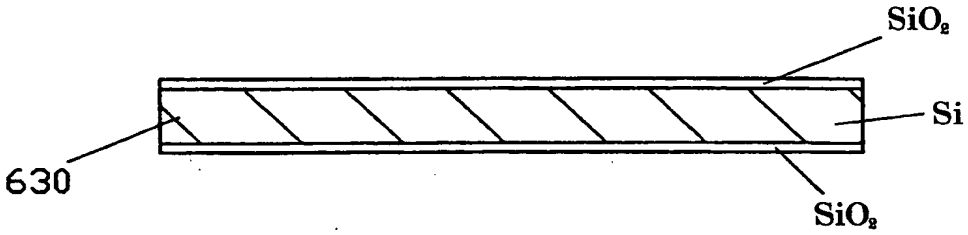


FIG. 6K

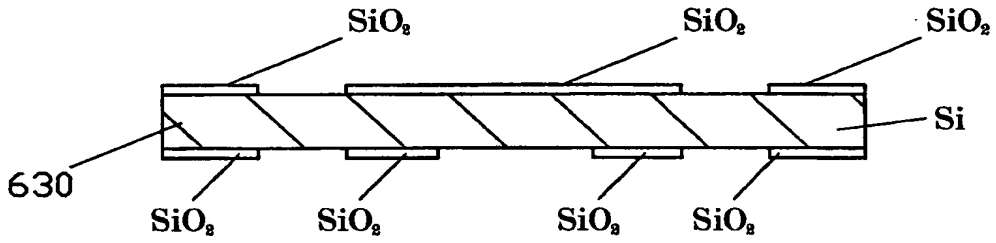


FIG. 6L

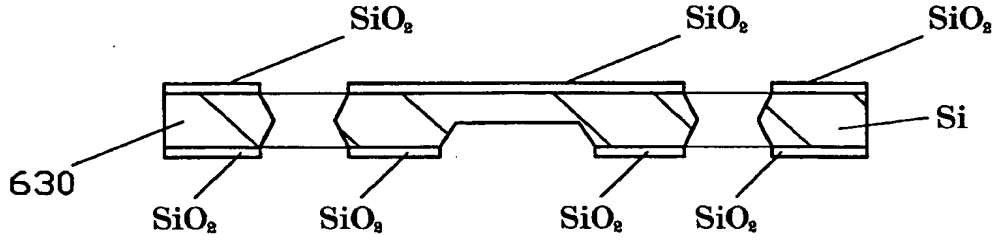


FIG. 6M

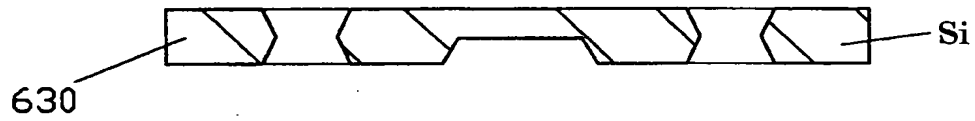


FIG. 6N

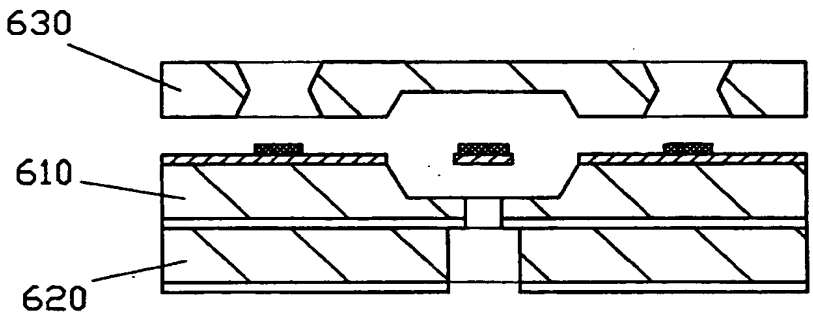


FIG. 6O

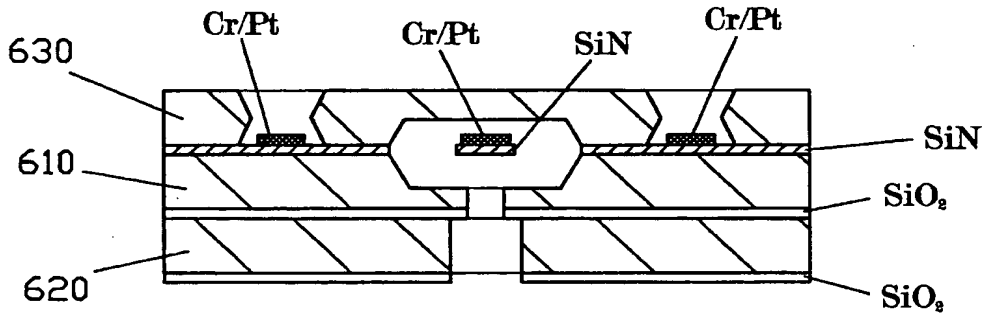


FIG. 6P

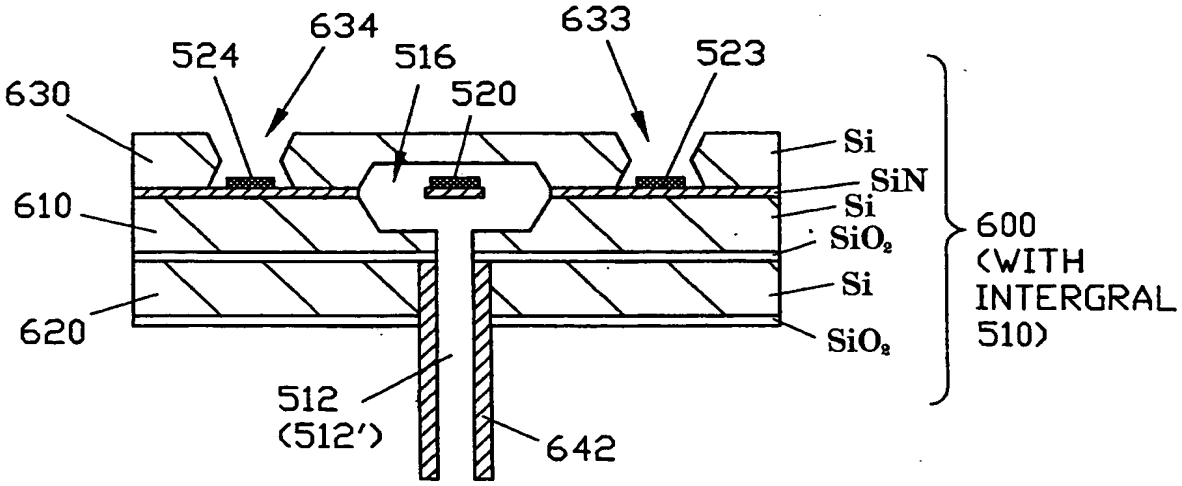


FIG. 7A

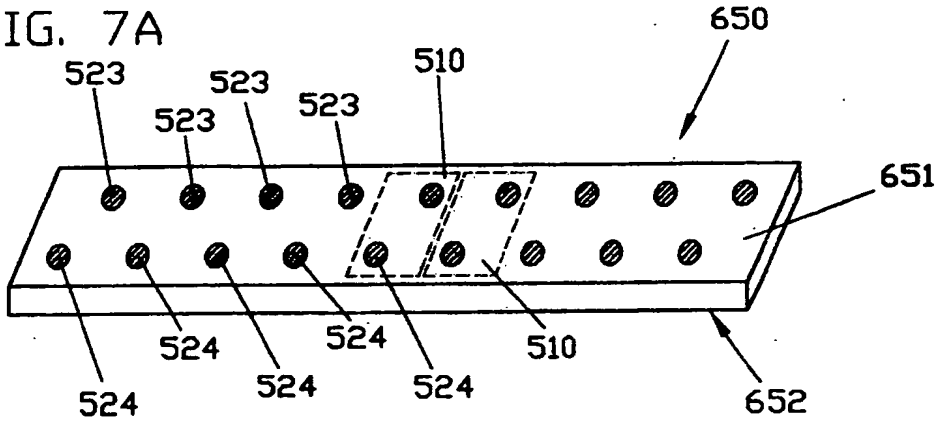


FIG. 7B

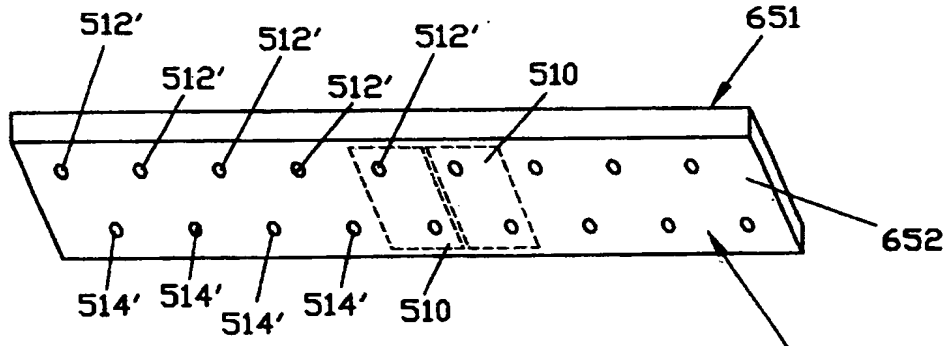


FIG. 7C

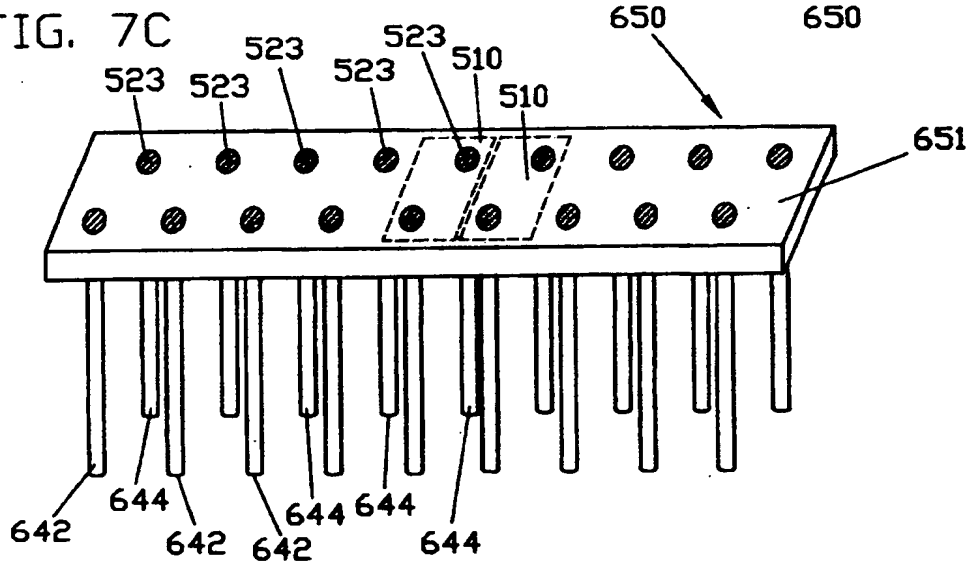


FIG. 7D

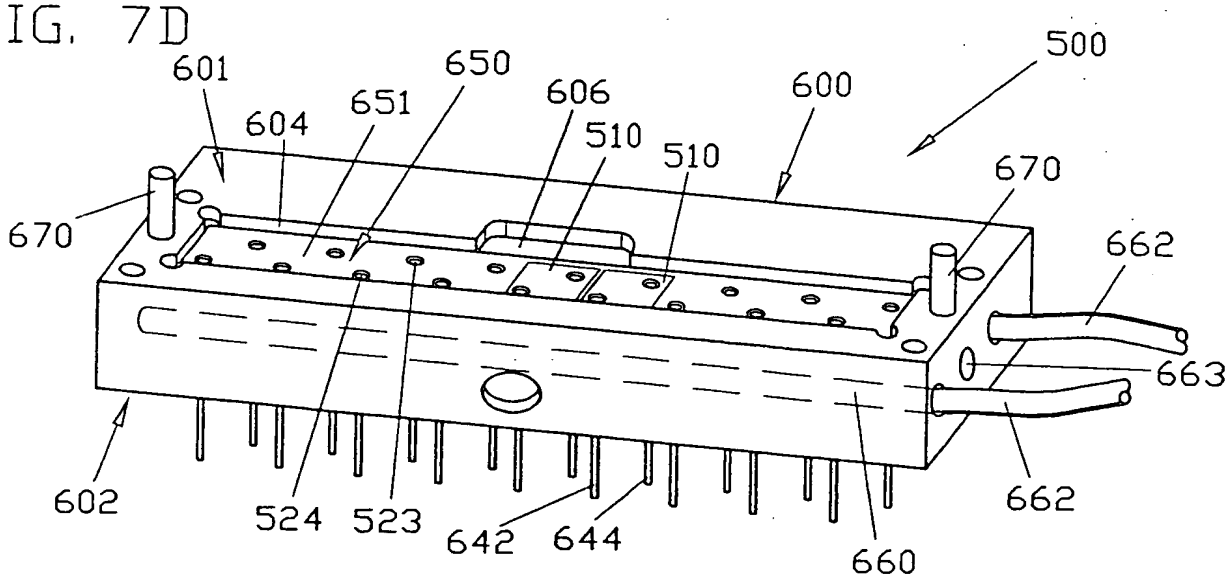

601
650
606
600
500
604
651
510
510
670
670
662
663
602
524
523
642
644
660
662

FIG. 7E

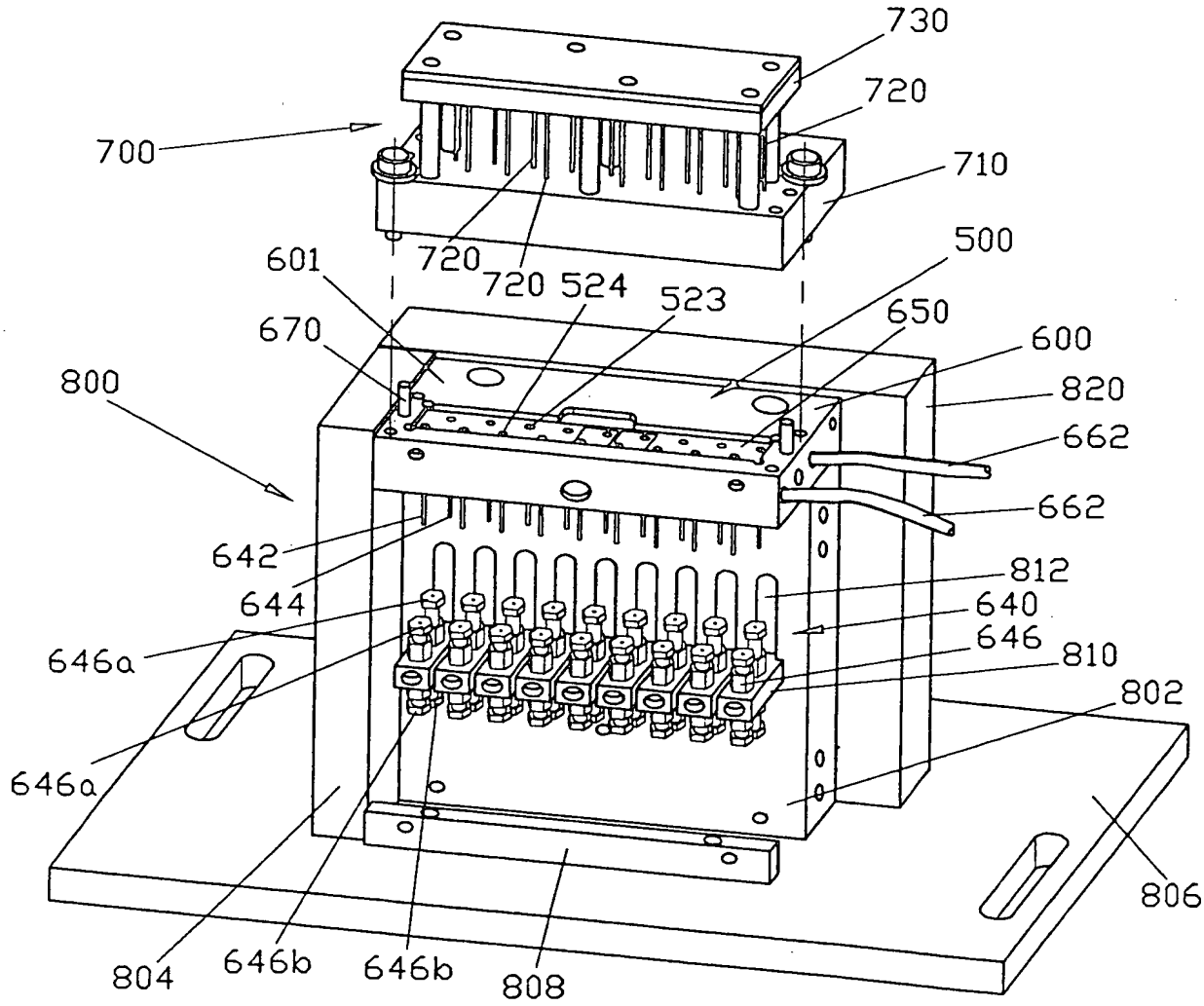

730
720
700
710
601
720
720
524
523
500
670
650
600
800
820
662
662
642
644
812
640
646a
646
810
802
646a
806
804
646b
646b
808

FIG. 7F

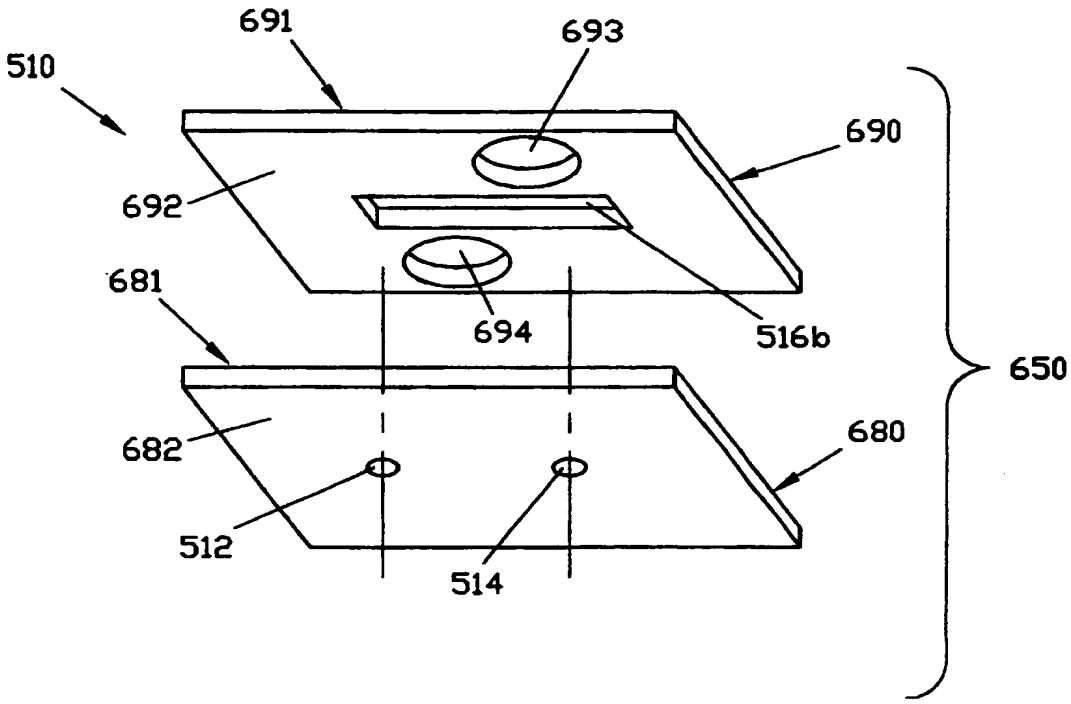

691
693
510
690
692
681
694
516b
650
682
680
512
514

FIG. 7G

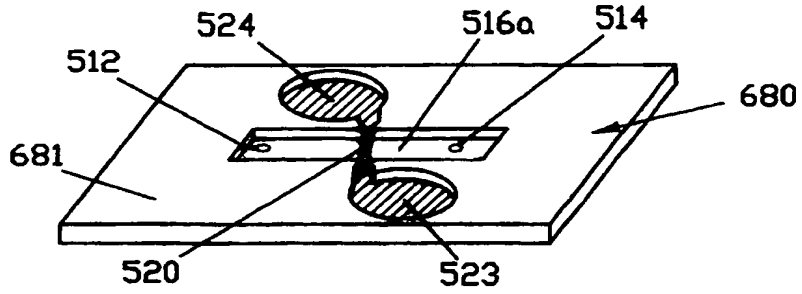

524
516a
514
512
680
681
520
523

FIG. 7H

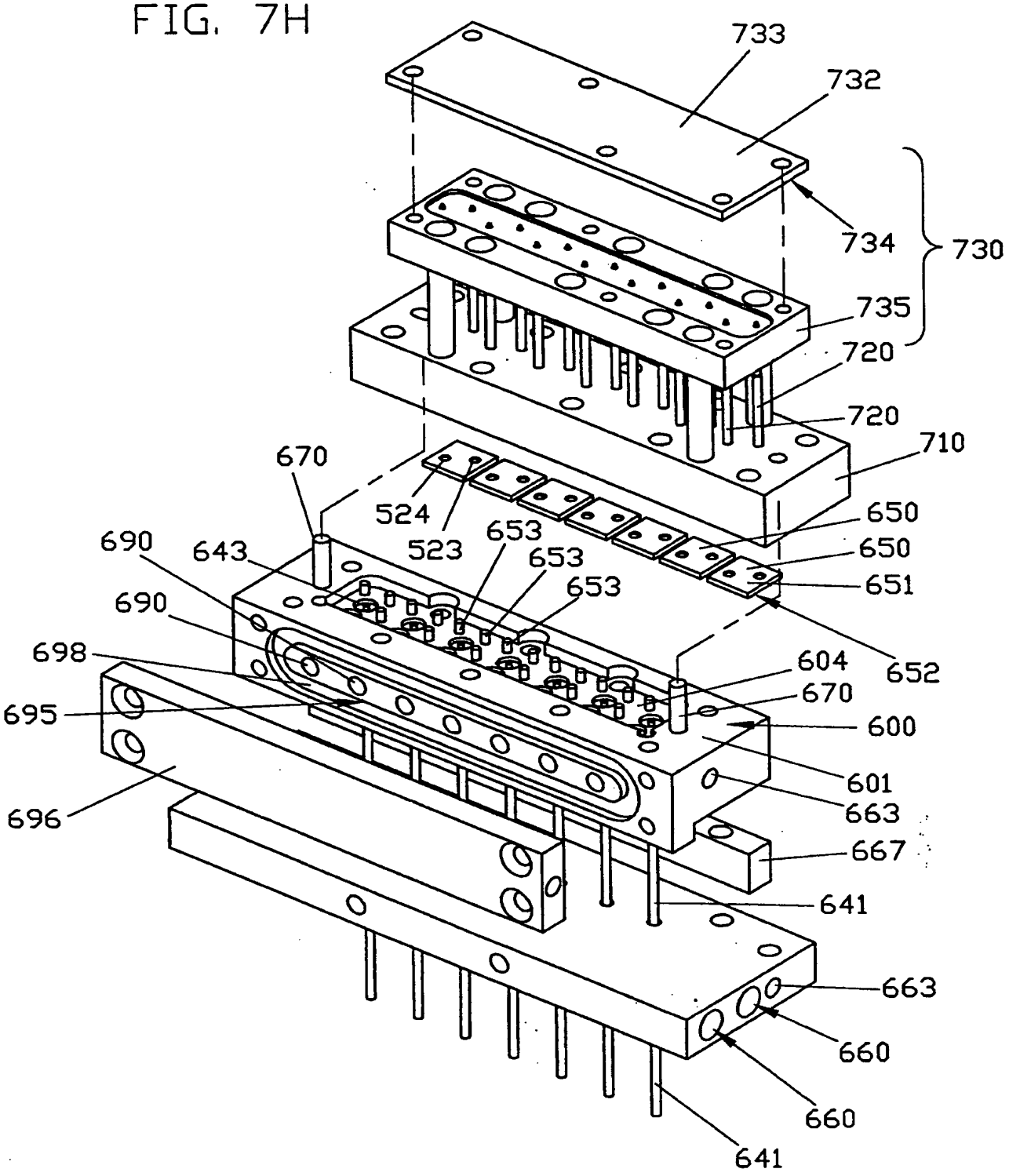

733
732
734
730
735
720
720
710
670
524
523
653
653
653
650
650
651
652
690
643
690
698
695
696
604
670
600
601
663
667
641
663
660
660
641

FIG. 7I

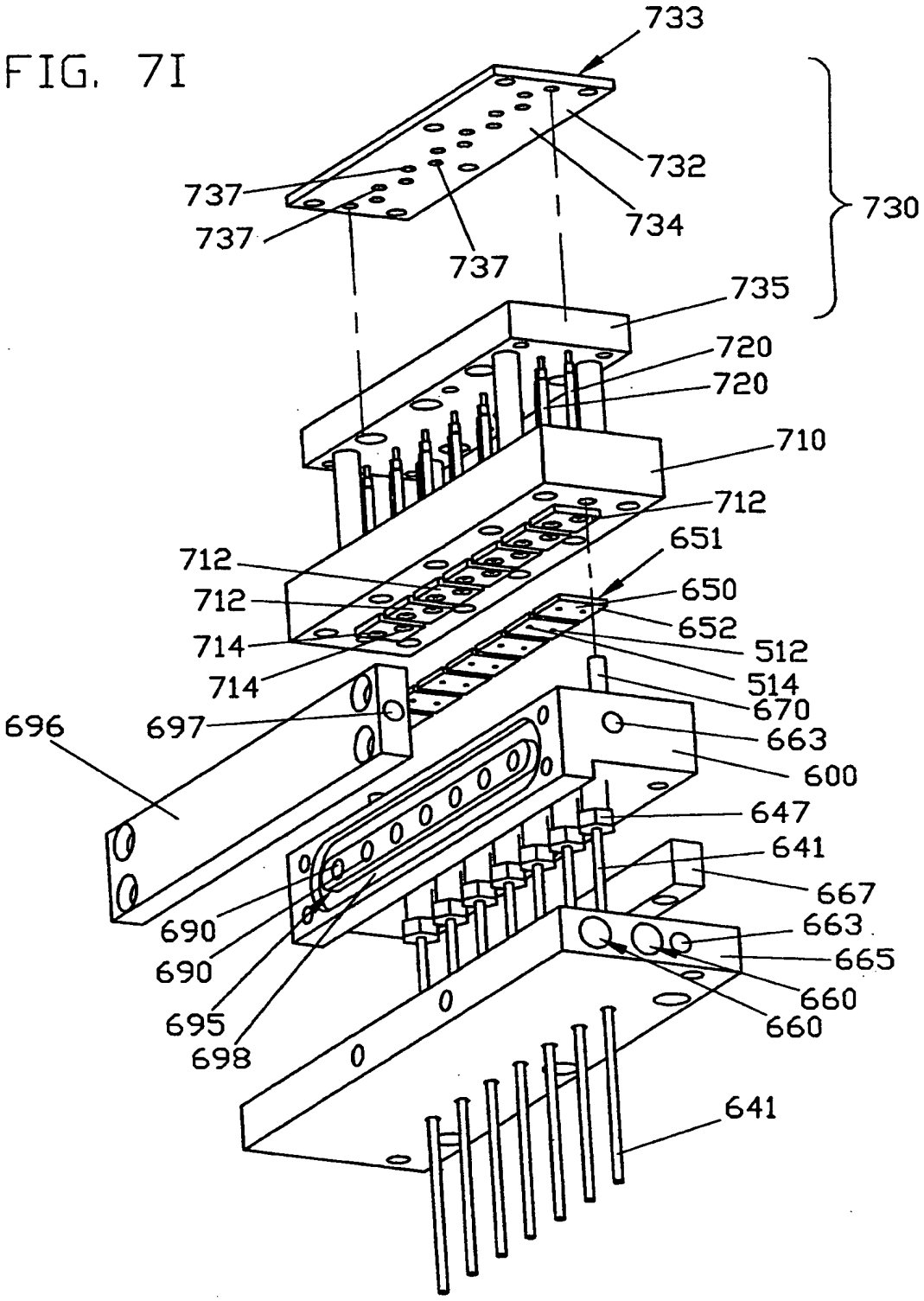

733
732
737
737
734
737
730
735
720
720
710
712
712
651
712
650
712
652
714
512
714
514
670
696
697
663
600
647
641
667
690
663
690
665
660
695
660
698
641

FIG. 7J

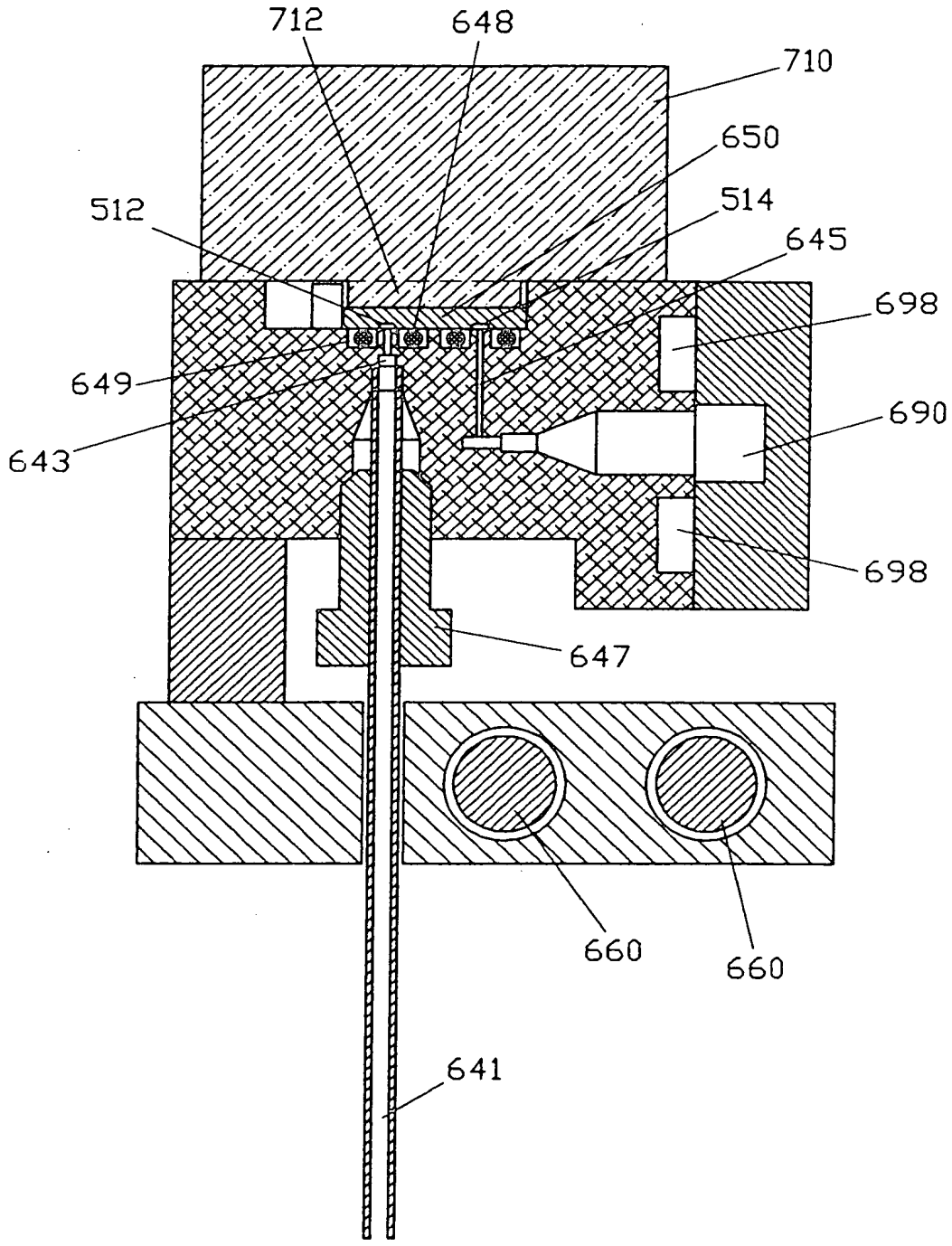
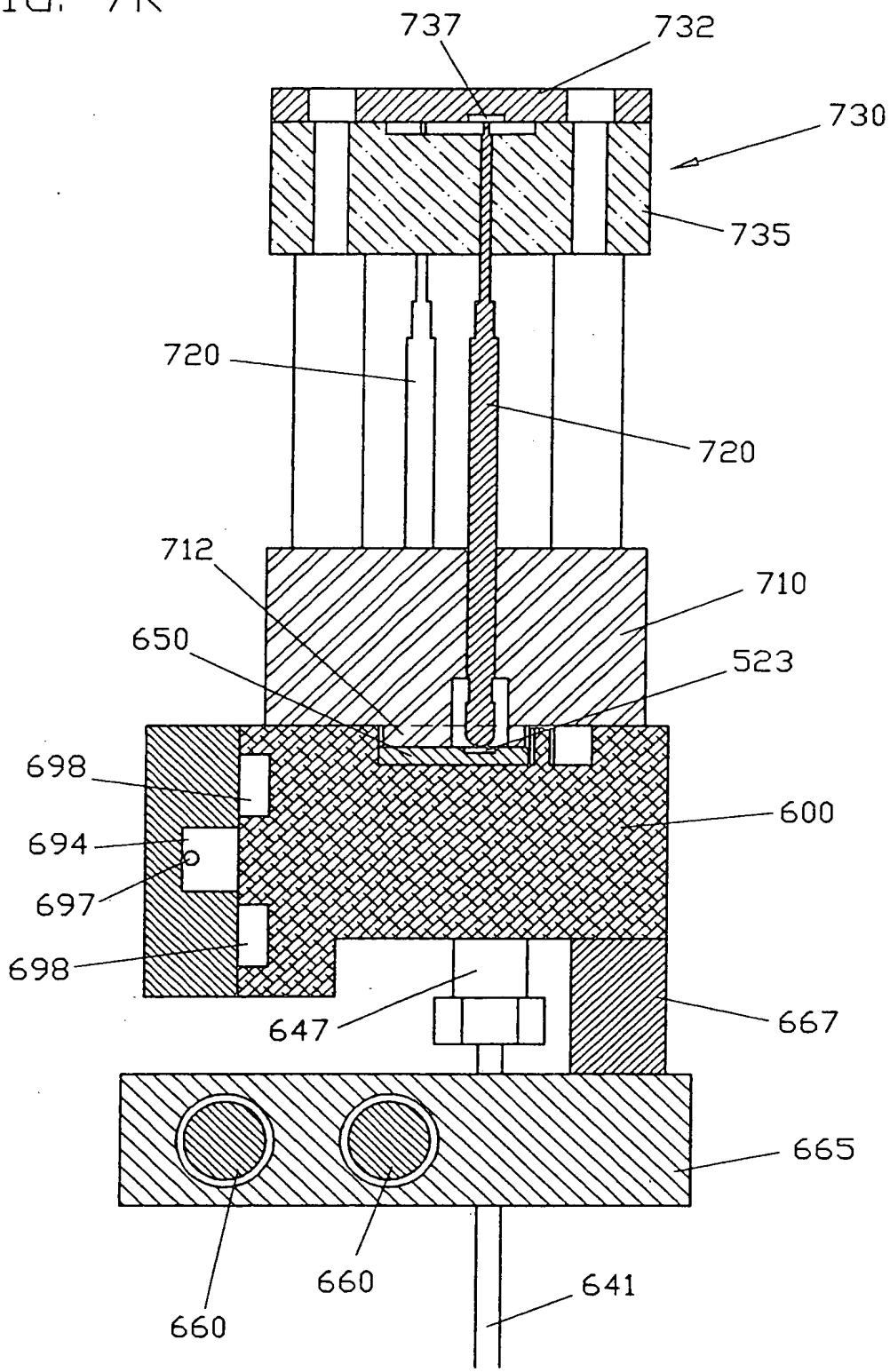


FIG. 7K


737
732
730
735
720
720
712
710
650
523
698
600
694
697
698
647
667
665
660
660
641

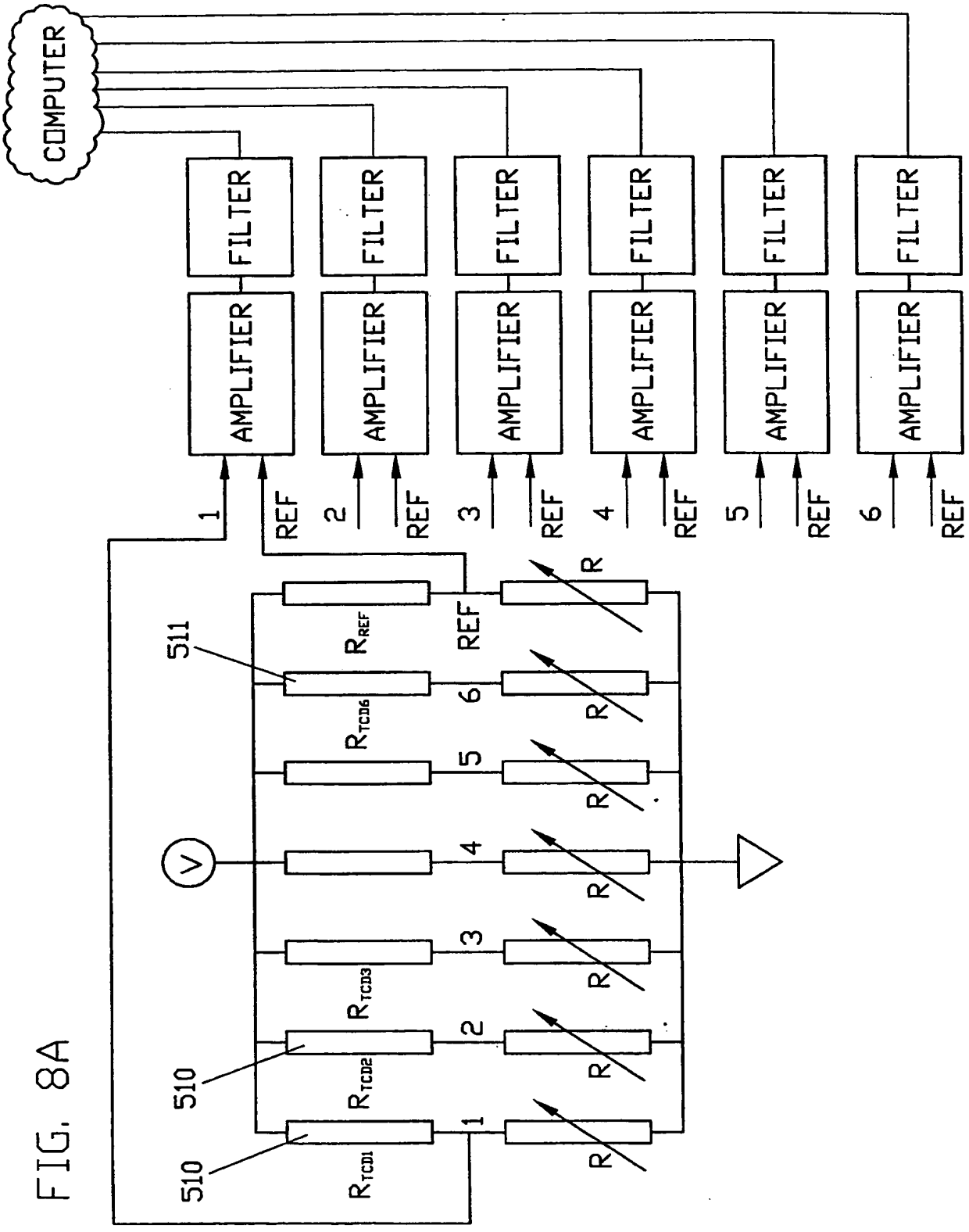
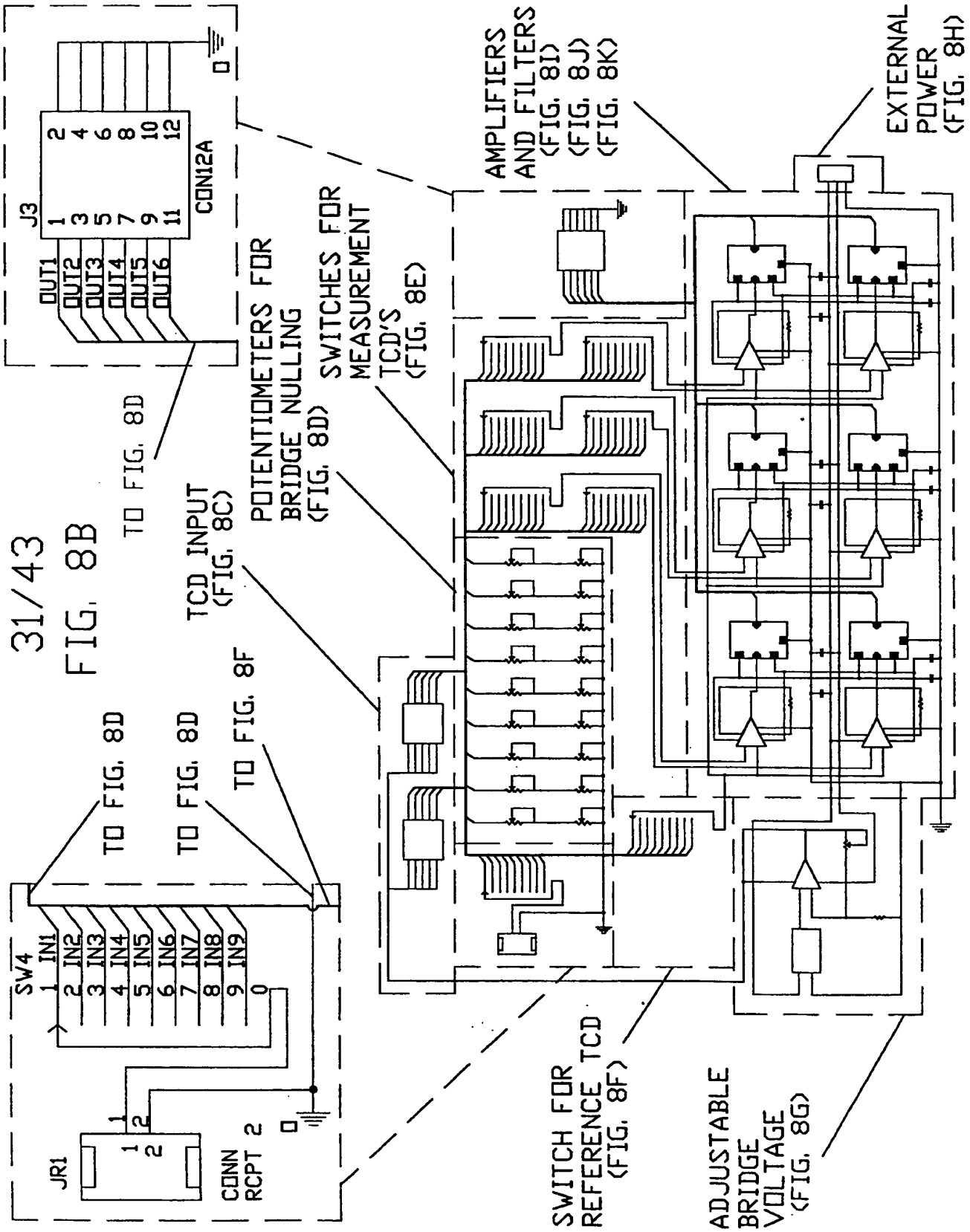

COMPUTER
FILTER
AMPLIFIER
1
REF
2
3
4
5
6
511
510
510
R_{REF}
R_{TCD6}
R_{TCD3}
R_{TCD2}
R_{TCD1}
R
V

FIG. 8A


31/43
FIG. 8B
J3
CON12A
OUT1
OUT2
OUT3
OUT4
OUT5
OUT6
TO FIG. 8D
POTENTIOMETERS FOR BRIDGE NULLING (FIG. 8D)
SWITCHES FOR MEASUREMENT TCD'S (FIG. 8E)
AMPLIFIERS AND FILTERS (FIG. 8I) (FIG. 8J) (FIG. 8K)
EXTERNAL POWER (FIG. 8H)
TCD INPUT (FIG. 8C)
TO FIG. 8D
TO FIG. 8D
TO FIG. 8F
SW4
IN1
IN2
IN3
IN4
IN5
IN6
IN7
IN8
IN9
JR1
CONN RCPT 2
SWITCH FOR REFERENCE TCD (FIG. 8F)
ADJUSTABLE BRIDGE VOLTAGE (FIG. 8G)

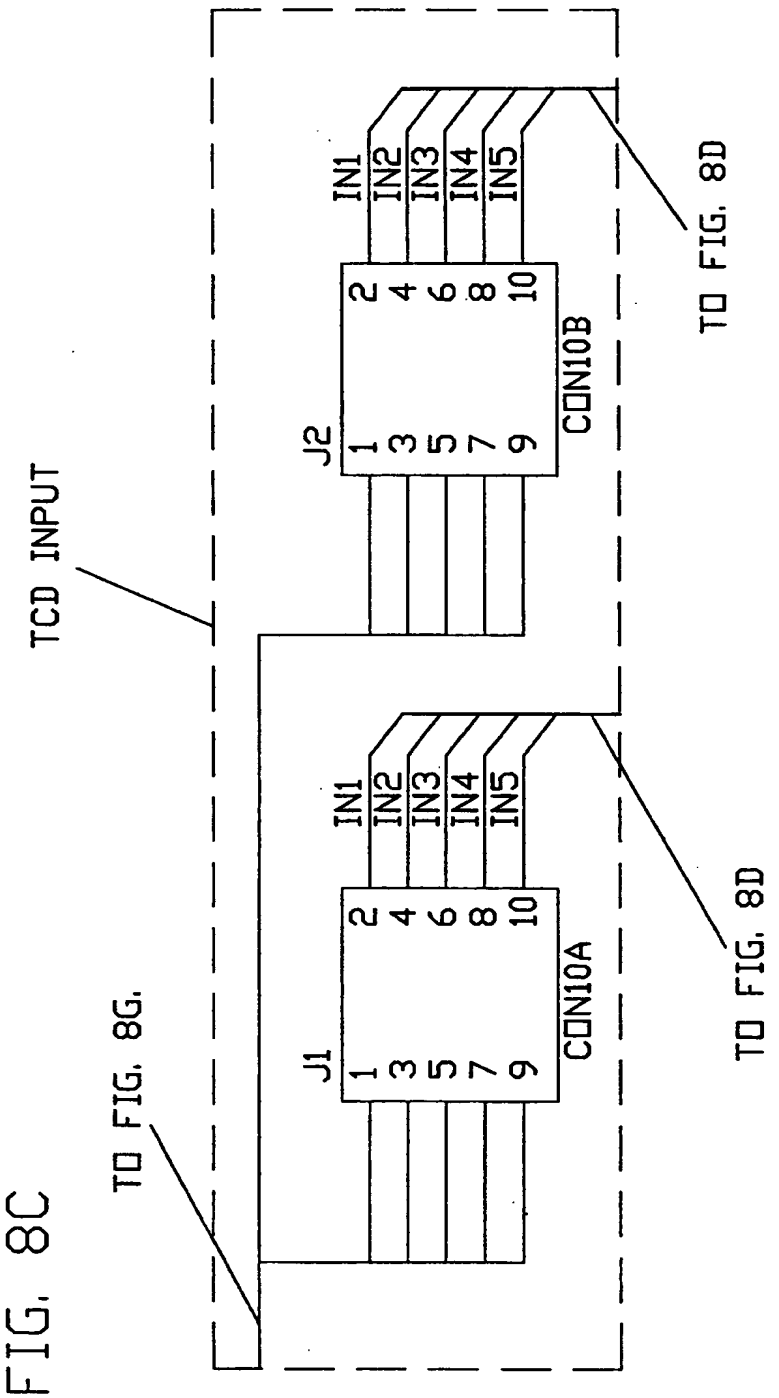
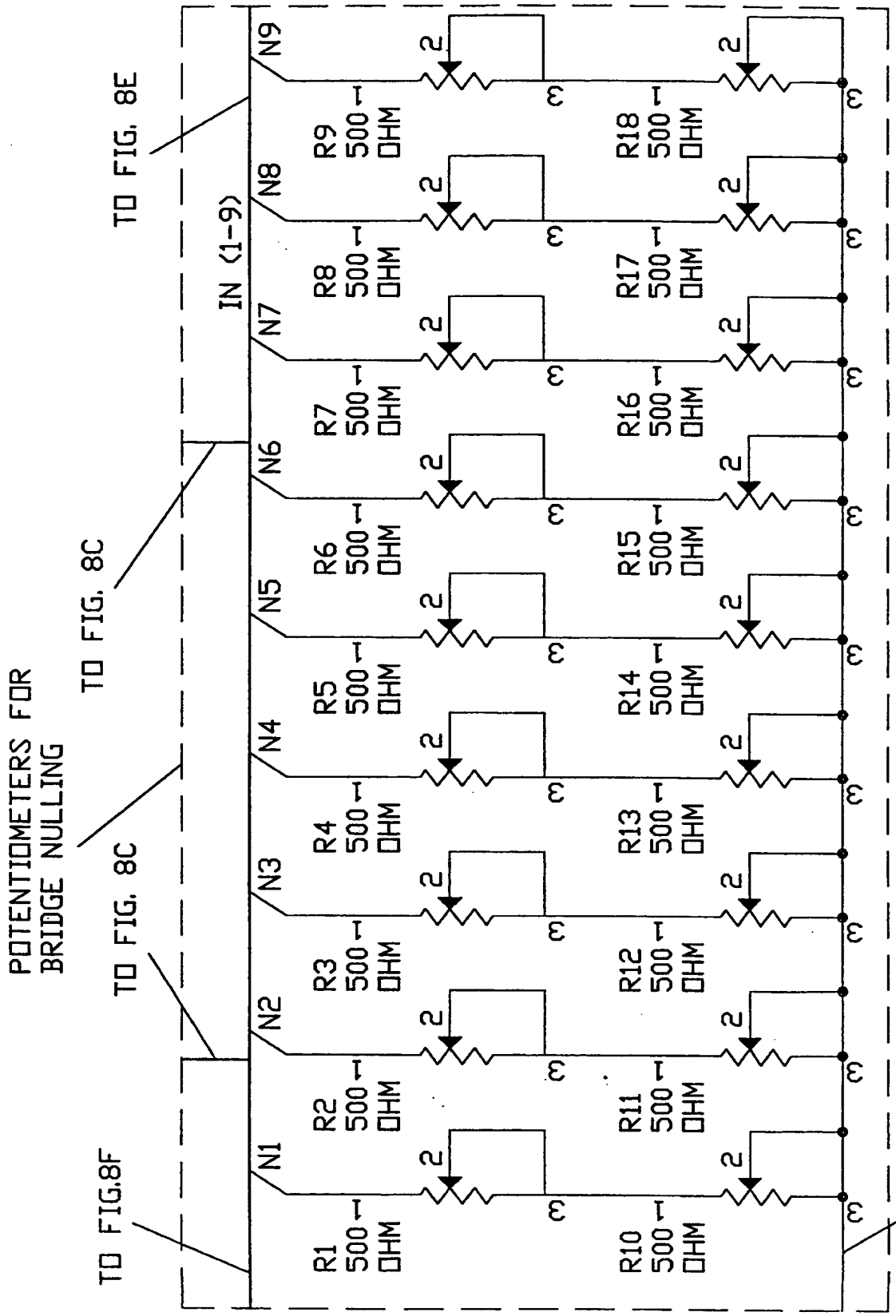

TCD INPUT
TO FIG. 8G.
J1
CON10A
J2
CON10B
1 3 5 7 9
2 4 6 8 10
IN1
IN2
IN3
IN4
IN5
TO FIG. 8D
TO FIG. 8D

FIG. 8C

FIG. 8D


TO FIG. 8E
TO FIG. 8C
TO FIG. 8C
TO FIG.8F
TO FIG. 8B
POTENTIOMETERS FOR
BRIDGE NULLING
IN (1-9)
N1
N2
N3
N4
N5
N6
N7
N8
N9
R1 500 OHM
R2 500 OHM
R3 500 OHM
R4 500 OHM
R5 500 OHM
R6 500 OHM
R7 500 OHM
R8 500 OHM
R9 500 OHM
R10 500 OHM
R11 500 OHM
R12 500 OHM
R13 500 OHM
R14 500 OHM
R15 500 OHM
R16 500 OHM
R17 500 OHM
R18 500 OHM

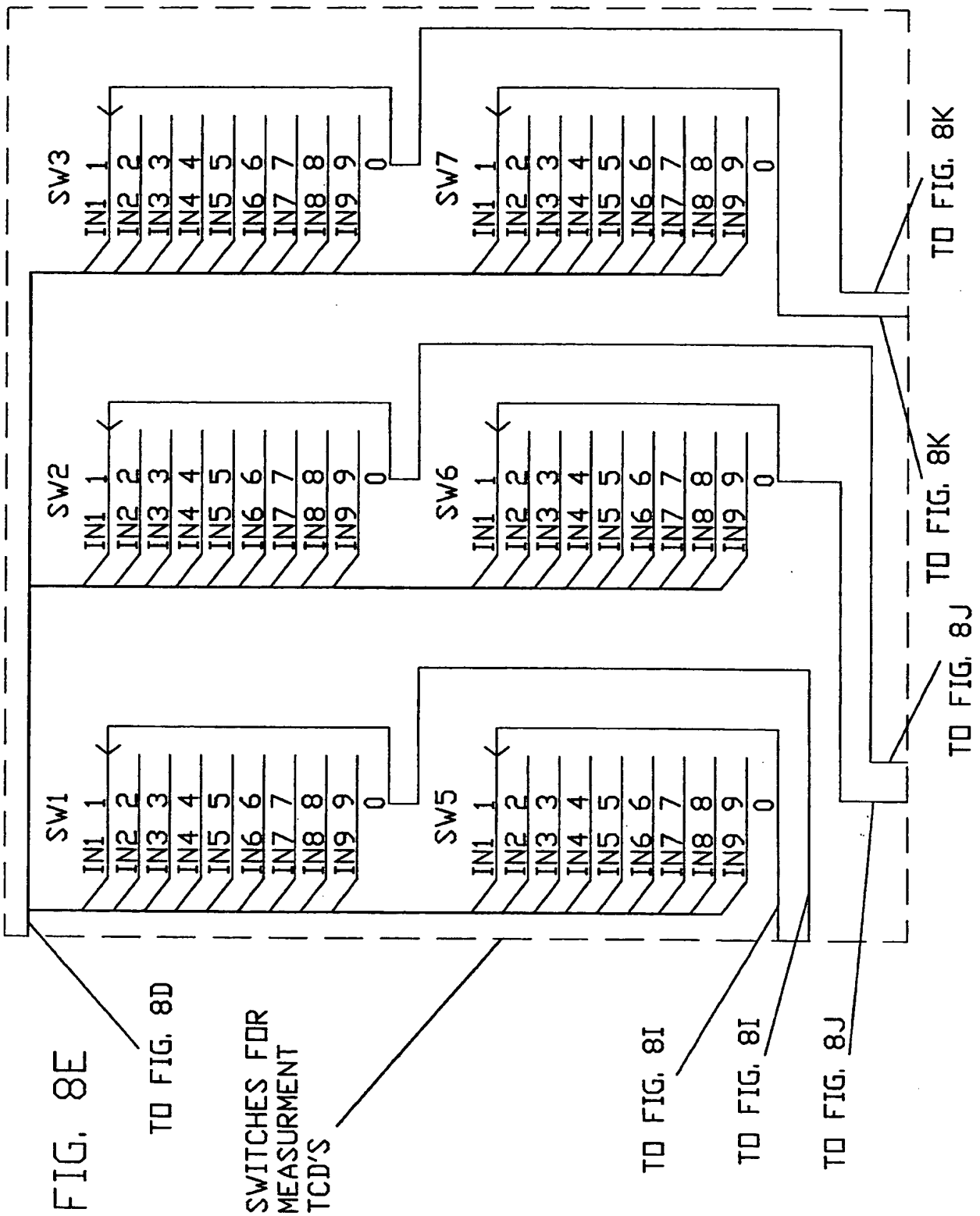

SW3
SW7
SW2
SW6
SW1
SW5
IN1 1
IN2 2
IN3 3
IN4 4
IN5 5
IN6 6
IN7 7
IN8 8
IN9 9
0
TO FIG. 8K
TO FIG. 8K
TO FIG. 8J
TO FIG. 8J
TO FIG. 8D
SWITCHES FOR MEASURMENT TCD'S
TO FIG. 8I
TO FIG. 8I
TO FIG. 8J

FIG. 8E

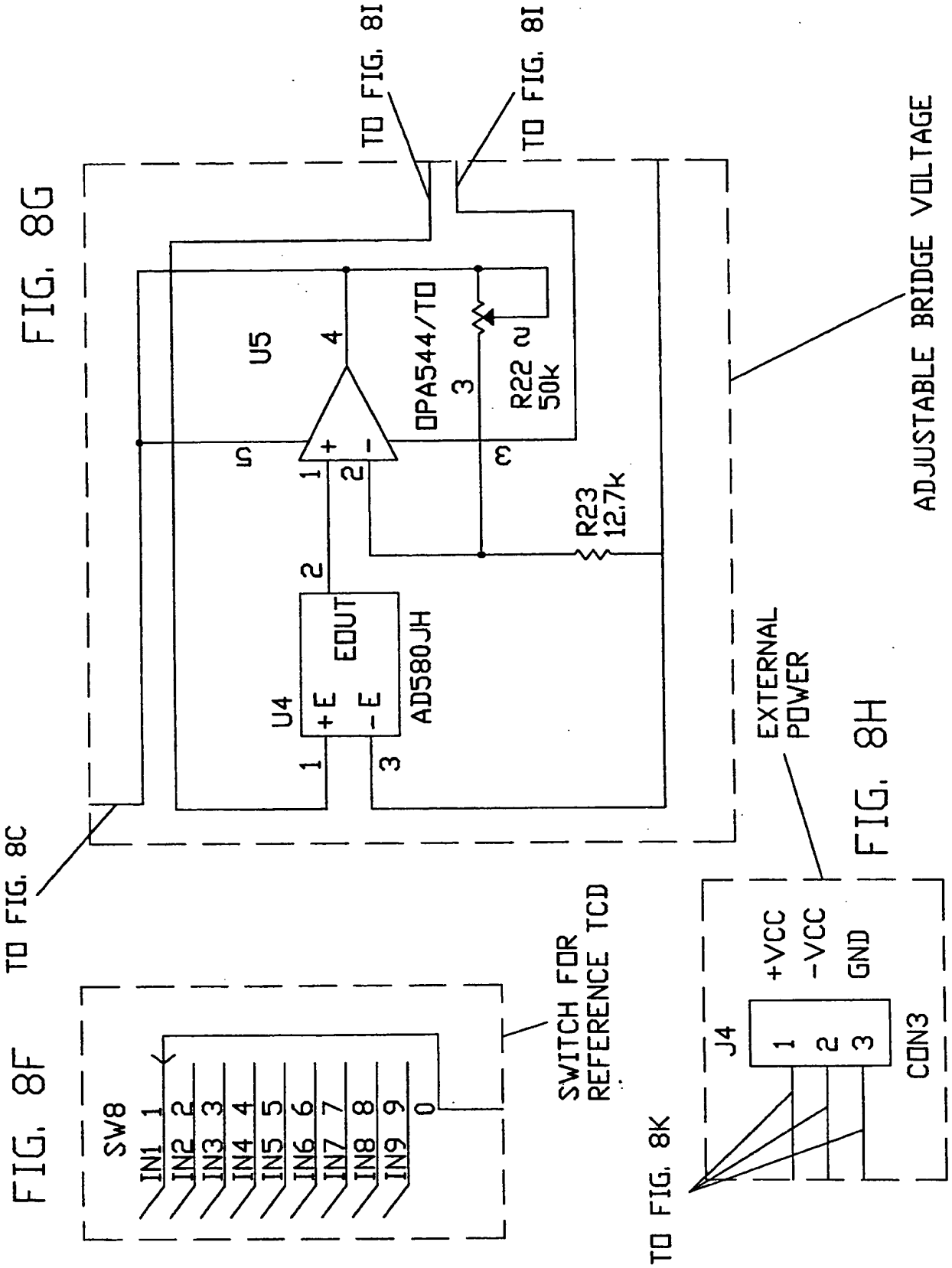


FIG. 8G
TO FIG. 8I
TO FIG. 8I
U5
4
OPA544/TO
3
R22 ω
50k
5
+
-
1
2
6
R23
12.7k
2
U4
+E
EOUT
-E
AD580JH
1
3
ADJUSTABLE BRIDGE VOLTAGE
TO FIG. 8C
EXTERNAL
POWER
FIG. 8H
FIG. 8F
SW8
IN1 1
IN2 2
IN3 3
IN4 4
IN5 5
IN6 6
IN7 7
IN8 8
IN9 9
0
SWITCH FOR
REFERENCE TCD
J4
1
2
3
+VCC
-VCC
GND
CON3
TO FIG. 8K

FIG. 8I

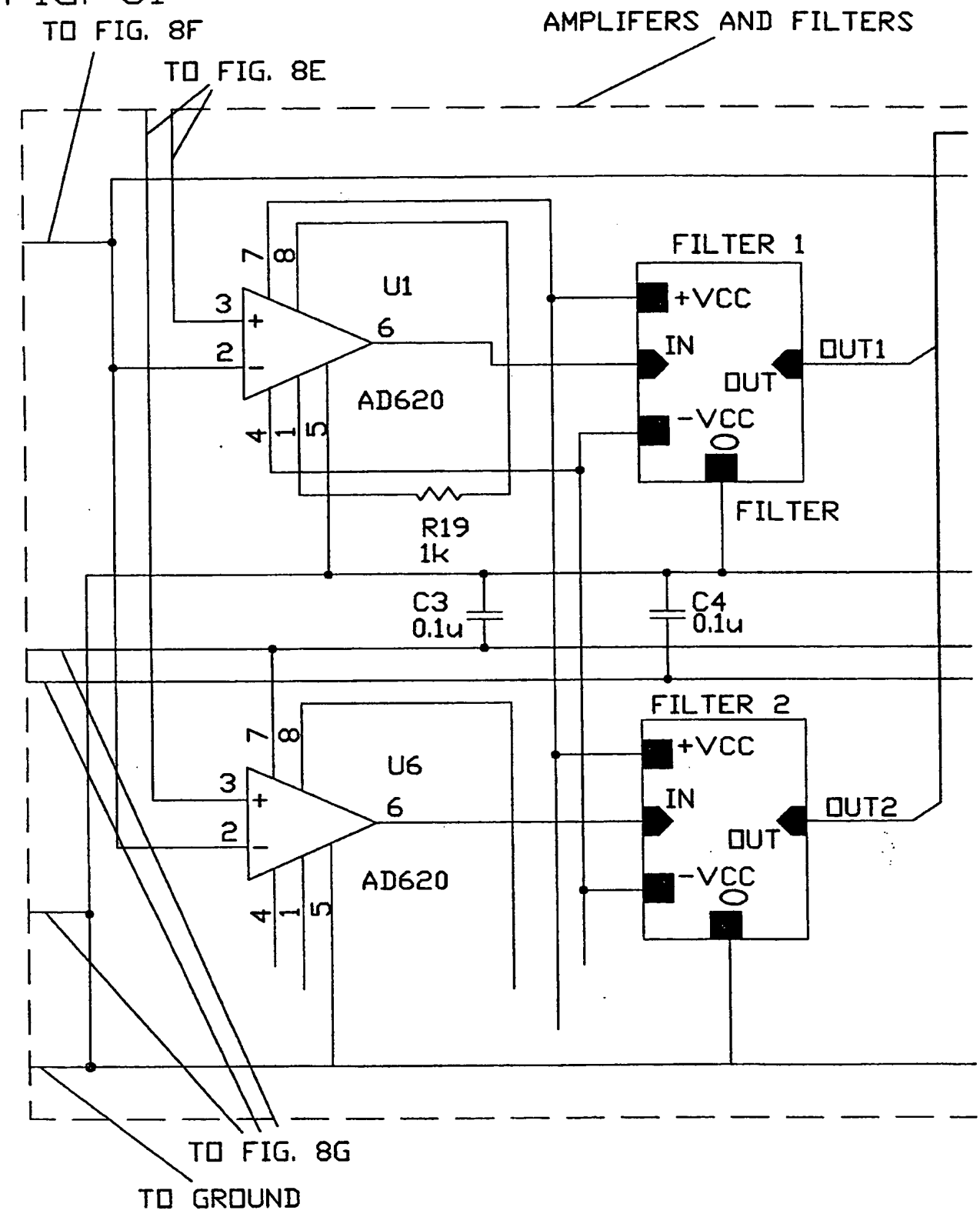

TO FIG. 8F
TO FIG. 8E
AMPLIFERS AND FILTERS
U1
AD620
R19
1k
C3
0.1u
C4
0.1u
FILTER 1
+VCC
IN
OUT
-VCC
FILTER
OUT1
U6
AD620
FILTER 2
+VCC
IN
OUT
-VCC
OUT2
TO FIG. 8G
TO GROUND

FIG. 8J

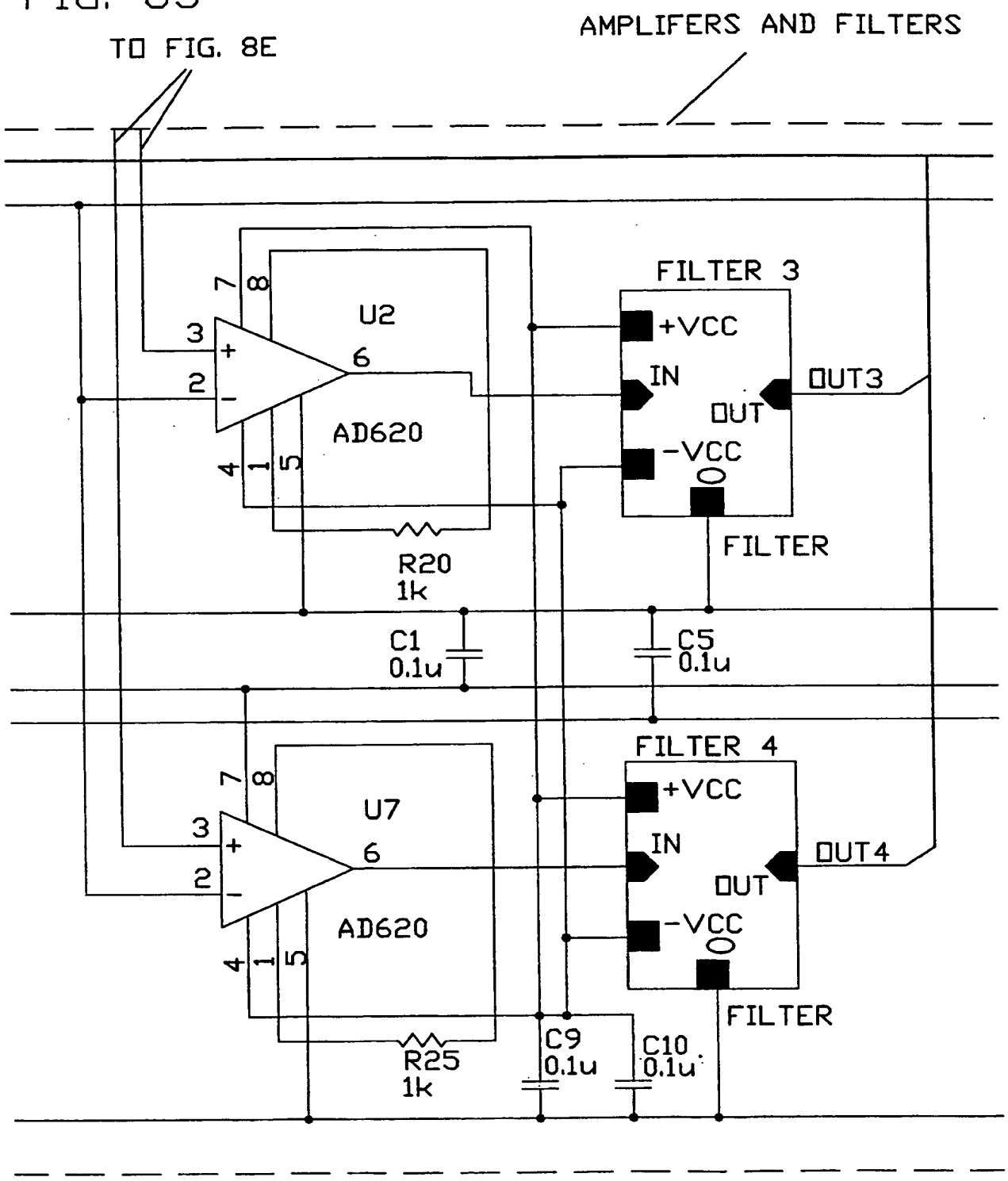
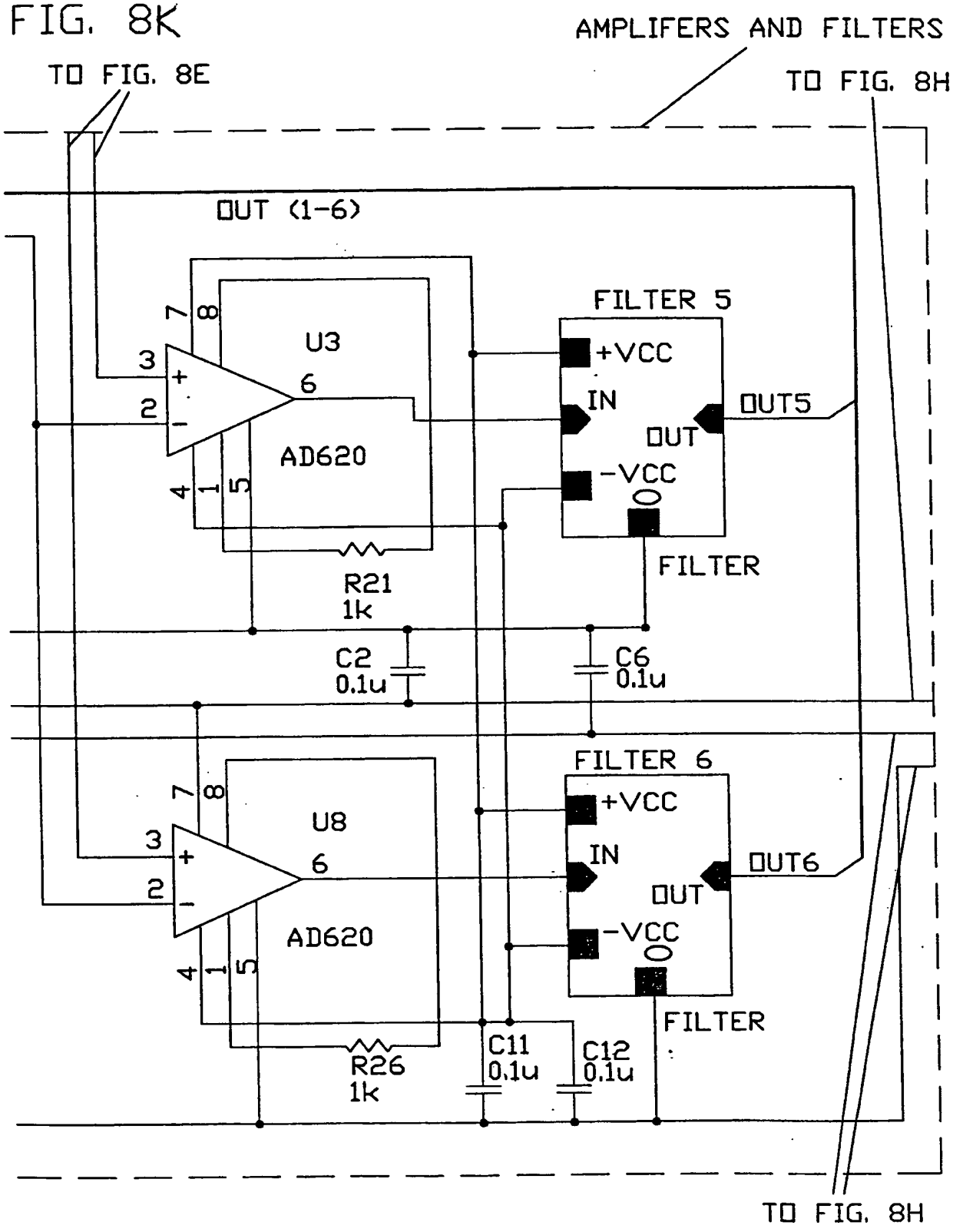

AMPLIFERS AND FILTERS
TO FIG. 8E
U2
AD620
R20
1k
C1
0.1u
FILTER 3
+VCC
IN
OUT
-VCC
FILTER
OUT3
C5
0.1u
U7
AD620
R25
1k
C9
0.1u
C10
0.1u
FILTER 4
+VCC
IN
OUT
-VCC
FILTER
OUT4

FIG. 8K


AMPLIFERS AND FILTERS
TO FIG. 8E
TO FIG. 8H
OUT (1-6)
U3
AD620
FILTER 5
+VCC
IN
OUT5
OUT
-VCC
FILTER
R21
1k
C2
0.1u
C6
0.1u
U8
AD620
FILTER 6
+VCC
IN
OUT6
OUT
-VCC
FILTER
R26
1k
C11
0.1u
C12
0.1u
TO FIG. 8H

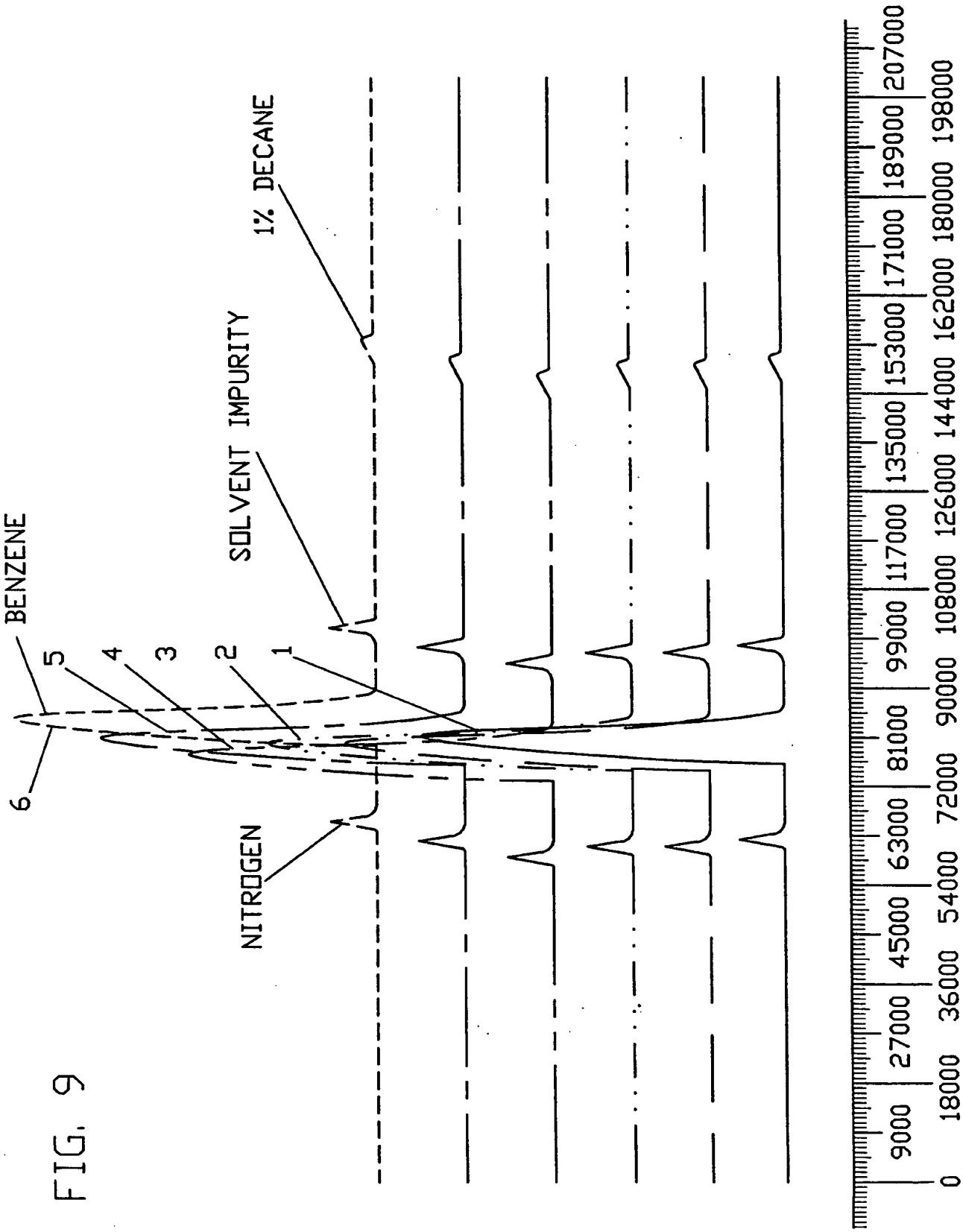

BENZENE
5
4
3
2
1
SOLVENT IMPURITY
1% DECANE
6
NITROGEN
0
9000
18000
27000
36000
45000
54000
63000
72000
81000
90000
99000
108000
117000
126000
135000
144000
153000
162000
171000
180000
189000
198000
207000

FIG. 9

FIG. 10A

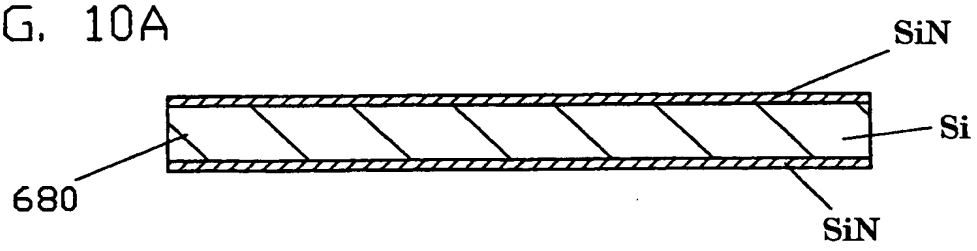


FIG. 10A

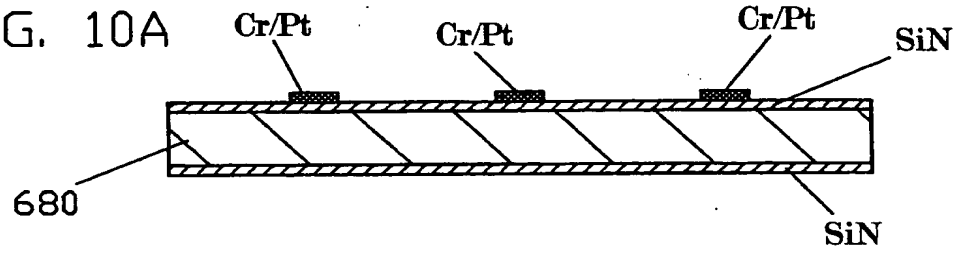


FIG. 10C

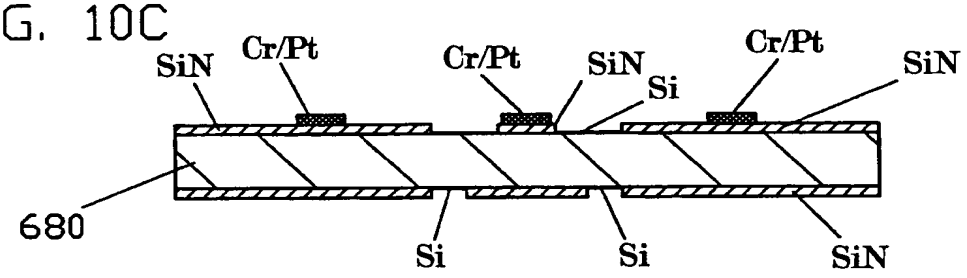


FIG. 10D

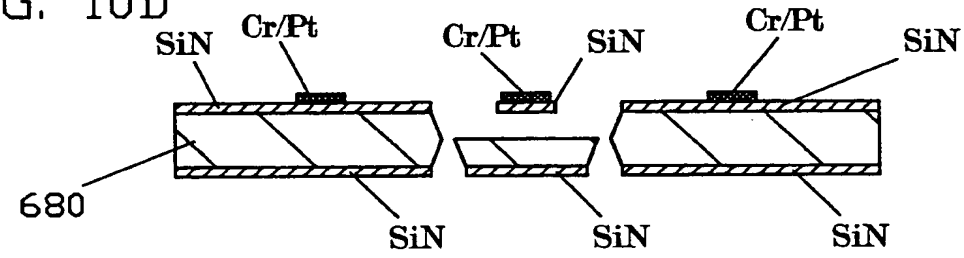
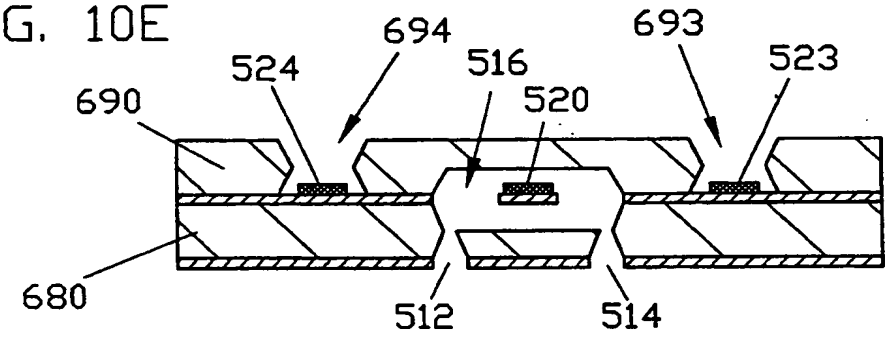


FIG. 10E



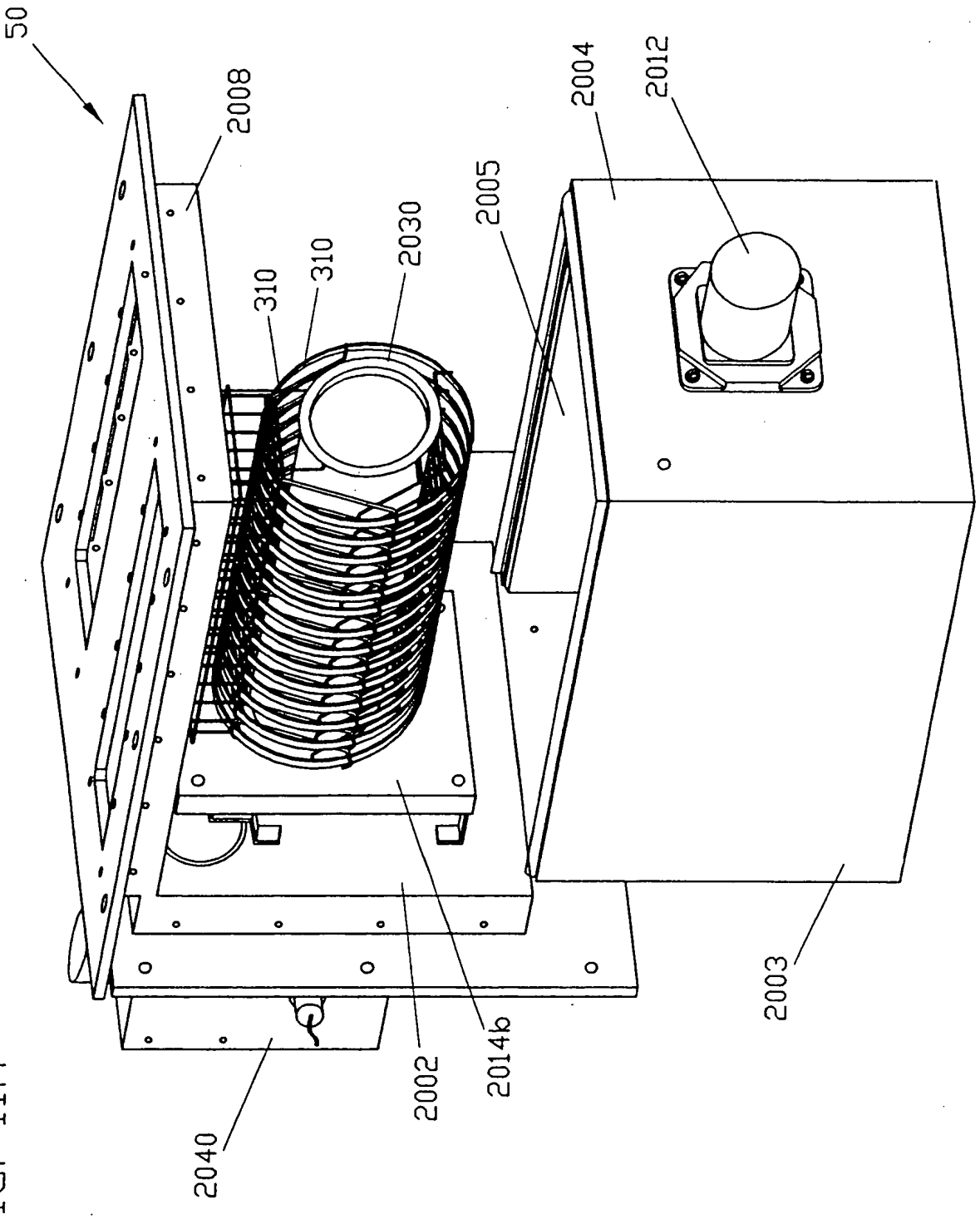


FIG. 11A

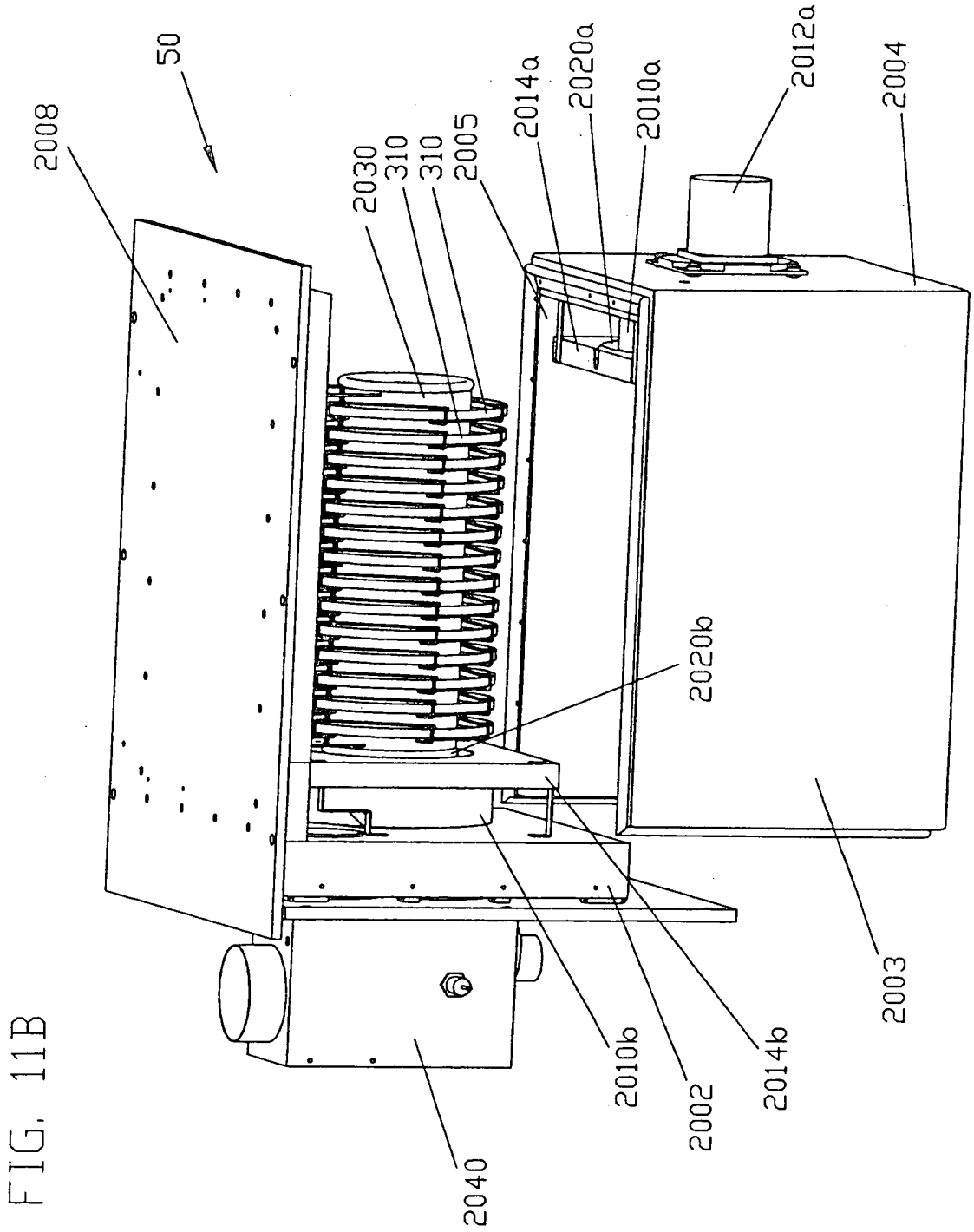

50
2008
2030
310
310
2005
2014a
2020a
2010a
2012a
2004
2020b
2010b
2002
2014b
2003
2040

FIG. 11B

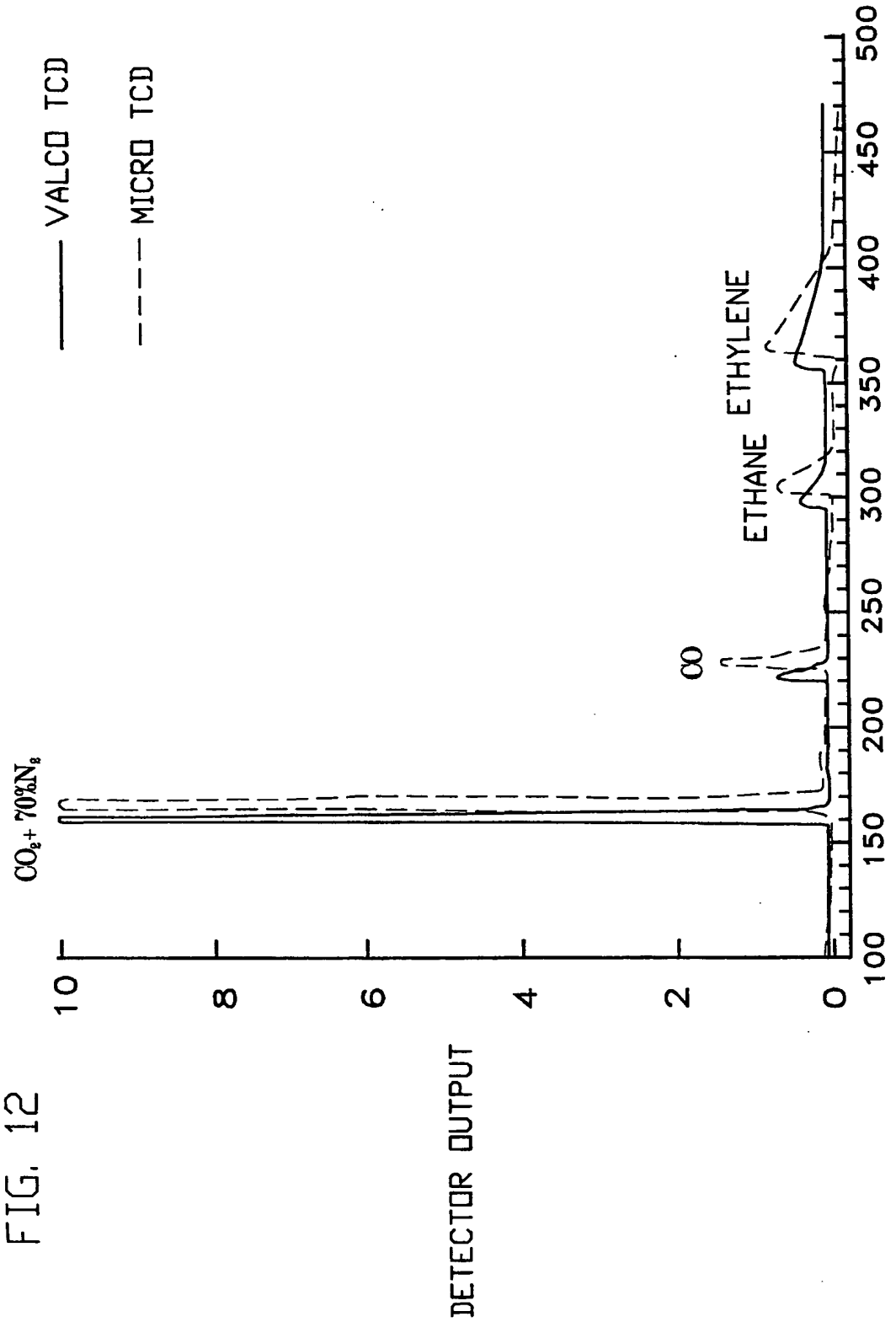

VALCO TCD
MICRO TCD
CO_2+ 70%N_2
CO
ETHANE
ETHYLENE
DETECTOR OUTPUT
TIME (SECONDS)
0
2
4
6
8
10
100
150
200
250
300
350
400
450
500

FIG. 12